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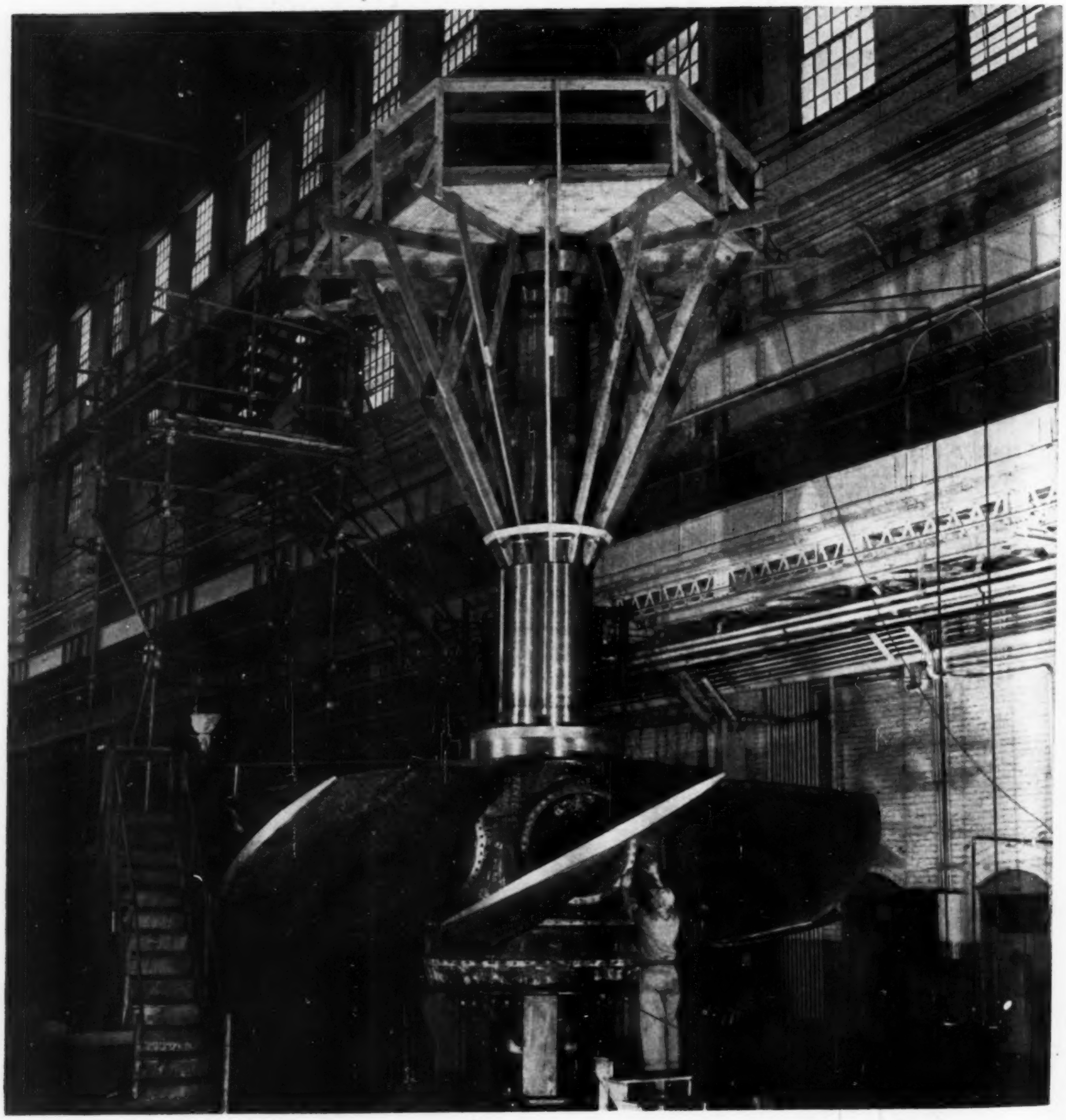

T.V.A. Kentucky Power Plant Turbine Runner

(Huge adjustable blade Kaplan runner and shaft assembly for fifth unit of T.V.A.'s Kentucky Dam was recently completed in the erection shops of the Allis-Chalmers Manufacturing Company. The runner is nearly 22 ft in diameter with its main shaft extending almost 26 ft above runner. Turbine rating is 44,000 hp under operating head of 48 ft.)

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GEORGE A. STETSON, *Editor*

E.C.P.D. Fifteenth Anniversary

IN commemoration of its fifteenth anniversary, the Engineers' Council for Professional Development has issued a 16-page booklet, "E.C.P.D., a Challenge," described as "an audit of accomplishments, 1932–1947, and a rededication of plans for future action."

In the light of the accomplishments of E.C.P.D. the financial burden it has placed on the constituent bodies has been practically negligible. Its most costly work, in accreditation and in student selection and guidance, has been financed in the one case by the fees paid by the colleges and in the other by a grant of funds from the Carnegie Foundation for the Advancement of Teaching. A small source of income is found in the sale of E.C.P.D. publications. But the services of the engineers who have made up its committees and worked on its projects have been freely and unstintedly given for the sake of the nation and the engineering profession. To one who has been close to the venture from its start this proof of devotion and service inspires admiration and confidence that the future of E.C.P.D. and the engineering profession is bright. But no worth-while project can realize its full potentialities on devotion and voluntary service of unselfish men alone. It must be adequately financed. The record of the past fifteen years commands not only respect and commendation but more generous financial support of the continuing program of the future.

What is this continuing program of the future? In broad terms it covers the areas of student selection and guidance, of engineering education, of the training of young graduates during the early years of their careers prior to full professional maturity, and the means, formal and otherwise, by which that maturity finds recognition by the engineering profession and by the public.

The record of the past fifteen years in the first two of these areas has been noteworthy and satisfactory. With the start that has been made there is little doubt that progress will continue. The work is specific and technical in character and can be carried on, provided funds are available, by groups of experts. It is the second two areas, professional training and professional recognition, in which accomplishments to date have been most difficult to assess and in which future progress has the greatest opportunity for growth. It is in these areas that bold imagination can devise worth-while programs.

What more challenging, what more rewarding task is there for engineers than lies in this area of professional training? Yet how much more difficult it is of accomplishment than the tasks of influencing selection and education, which are specific and can be handled by relatively small groups of experts dealing with institutions whose function it is to select and educate. Once the young engineer is graduated he must be thought of as an individual. These young men cease to exist as relatively few groups living under fairly well regulated conditions. They are scattered under a vastly greater number of employers and live under vastly more varied conditions. To be effective, work in the area of professional training must touch the individual intimately, and there is no easy criterion of success like a diploma. Similarly the burden to be borne in developing this area cannot be confined to relatively small committees, whose function at best is program and planning, but must be shared by hundreds of professional and public-minded engineers of maturity, personality, and sound judgment. What E.C.P.D. hopes to accomplish in this area is indicated by means of a chart in the booklet. Here the rate of progress in knowledge, experience, and judgment, from boyhood to maturity, is shown by two curves. In one, "present trend after graduation," this rate of progress is stationary for several years after graduation. In the other, "trend under professional training," the rate of progress established in college is maintained throughout the first year after graduation. The result of the second "trend" is to achieve the maturity or recognition level several years earlier than is now the case. Granted that the diagram is a generalization without quantitative or statistical confirmation, it does present the problem and the opportunity graphically. What more satisfying service could an engineer render than to assist in pushing this professional-training trend line upward to occupy the position visualized as desirable by E.C.P.D.?

In the area of professional recognition we return to a task only one portion of which can be carried on by relatively small committees dealing with a relatively small number of professional societies. Here the concern is also for the individual, but here also certain measures of performance exist—full membership in a professional society, license to practice engineering, for example. Definitions and standard membership practices and labels are involved. But there are other portions of a program of professional recognition. It is a portion of the area in which the means, and not the objectives, may be matters of controversy. It is vast, almost limitless in extent. One of the great problems it poses is to break it up into projects specific enough to be clearly stated and effectively and enthusiastically prosecuted. The projects themselves will require organization, direction, and a vast number of willing workers. Success waits on the ability of engineers to think of themselves and their work as a profession, on their willingness to accept self

and public forms of regulation. For unless engineers honestly recognize themselves they can hardly expect public recognition.

There is much to do in E.C.P.D.'s continuing program. E.C.P.D. can plan, it can recommend, it can exercise leadership, point the way, inspire, and exhort. The support of its program and the work in its projects is the responsibility of the constituent bodies and their members.

Improved Publication Service

MEMBERS of The American Society of Mechanical Engineers will have an opportunity within the next few weeks to express their opinion on a proposed modification of the Society's publication procedure designed to provide better service and to reduce costs and waste.

The proposals are the result of a study of Society expenses and services made by a special Survey Committee that was active for a couple of years. The results of these studies as they related to publications were turned over to the Publications Committee which formulated the new plan and submitted it to the Board on Technology, where it was approved in revised form and recommended for adoption. Approval by the Council was voted at the Chicago Meeting in June. Because the new plan involves changes in Society procedure the Council, on the recommendation of the Board, decided to submit the plan to letter ballot of the members. Ballots, with a description of the plan, will be mailed to members sometime in September.

The most important feature of the new plan is the establishment of a new department in MECHANICAL ENGINEERING in which an attempt will be made to present a digest of every paper presented at Society meetings, for which a manuscript exists, with the exception of papers otherwise published in full or in condensed form in MECHANICAL ENGINEERING. This new department, to be known as A.S.M.E. Technical Digest, is patterned after the Briefing the Record feature section which has won great popularity among readers and has showed up in the reader-interest poll as second only to feature articles in interest. Although the new digests will be somewhat briefer than Record items the treatment will be the same and they will be prepared with the object of telling not only the scope and purpose of the paper digested but enough of its substance to make the new department a readable source of up-to-the-minute information. The format has been designed for easy reading and includes illustrations. Each digest will be preceded by a description of the paper with its number so that readers who wish the complete article will be able to order a copy.

Under the former publication plan it has not been possible to publish more than 50 per cent of the papers presented at Society meetings. Members learned about other papers only through the announcement of their titles in programs. As for the papers that were published in Transactions or the *Journal of Applied Mechanics,* it has been necessary to await the appearance of these magazines, usually several months after the meeting. Complete papers are essential to a relatively few persons whose technical interest lies close to the subject matter and members whose interest is less intense but who wish to keep up to date on a wide variety of subjects find it burdensome to do so unless a readable comprehensive digest has been prepared for them. This the new plan proposes to do, not only in the case of papers that are eventually to be published in full but also for the remaining 50 per cent of papers that have been, up to now, not available in the publications. Hence for the first time in many years, since the number of papers has grown to the point where the expense has prohibited complete publication, will MECHANICAL ENGINEERING be able to offer, in whole or in digest form, every A.S.M.E. meeting paper. The popularity of "digest" magazines has convinced the Board that more A.S.M.E. papers will come to the active attention of members under the proposed plan than under the present plan.

In order to provide the new digest service in MECHANICAL ENGINEERING without increasing publications expense the Board recommends in its new plan the abandonment of the monthly Transactions. An annual volume will be published and may be purchased by libraries and anyone who wishes a complete set of Transactions papers. The *Journal of Applied Mechanics* will be continued but on a subscription basis and, as in the past, will be a part of the annual volume of Transactions.

The new plan will operate as follows: Upon receipt by the Editorial Department, papers for A.S.M.E. meetings will be put in "preprint" form. If they are assigned to A.S.M.E. Transactions, *Journal of Applied Mechanics,* or MECHANICAL ENGINEERING these preprints will be set in type; otherwise they will be mimeographed with photolithographed illustrations. Where time permits these preprints will be available for meeting use, and under a rule adopted this year they will be sold to members, either at the meeting or by mail. Papers not received in time for use at a meeting will be put in preprint form as soon as possible. Digests of these preprints will be published in MECHANICAL ENGINEERING and every member will have an opportunity to read the digests and order such preprints as he wishes to have in full. Preprints will also be available to nonmembers. The new plan not only makes more papers available but makes them available much more promptly. Papers assigned for publication in full in MECHANICAL ENGINEERING and the *Journal of Applied Mechanics* will be handled as formerly. There will be no change in the final publication of papers assigned to Transactions except they will not be sent to all members in the eight issues now distributed throughout the year but will appear in an annual volume (as at present) which must be purchased.

It is urged that every A.S.M.E. member read carefully the official description of the new publication plan, the essence of which has been presented in the foregoing, and the sample pages of the A.S.M.E. Technical Digest section to be added to MECHANICAL ENGINEERING if the plan is approved which will be mailed sometime in September, and register his vote for or against the proposal. If the proposal is accepted, the new plan will go into effect with the January issue and a greatly improved magazine will result.

ATOMIC-POWER ENGINEERING—

Some Design Problems

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INTRODUCTION

WITHIN the next few decades, a great many benefits from the conversion of nuclear mass to energy should affect many phases of our industrial economy and our daily life. Our economy should be stimulated by one product, atomic power. Our daily lives should benefit from another class of products, namely, radioactive isotopes for use in medicine, biology, and chemistry. Both may benefit from a third class of products, new synthetic elements such as neptunium, plutonium, americium, and curium. Of greatest significance in the last group is the synthetic atomic fuel (fissionable material or fissionable isotope) plutonium (Pu^{239}).[1] Similar to this is the synthetic fissionable isotope of uranium (U^{233}).[1] Both of these may augment our supply of the only significant natural fissionable isotope of uranium U^{235}.

It is quite significant that the "nuclear reactor" is the heart of most of the systems of devices through which these products may be obtained. Radioactive isotopes of natural stable elements can and have been made in particle accelerators such as the cyclotron. However, it is the nuclear reactor which holds promise of making them cheap enough and in sufficient quantities so that the horizon is broadened from a few applications literally to a multitude of possible uses. Fissionable material is of course the source of nuclear energy. The nuclear reactor is the device which does synthesize two new fissionable materials, U^{233} and Pu^{239}. Finally, of course, the nuclear reactor is the heart of an atomic-power system.

Because the nuclear reactor is so vital in all these phases of the nuclear-energy field, the future success of all is closely interwoven with progress in atomic power.

Obviously it is desirable for as much as possible of the nuclear-energy field to become self-supporting. Of the many possible sources of revenue, the demand for electric power ($3^1/_2$ billion dollars in 1946) is by far the largest market. Without offering proof, it may be safe to predict that the sale of electricity from atomic power is likely to form the basic large-dollar-volume industry enabling our society to benefit fully from nuclear energy. Thus, the development of economic power is much more important than as just a means to save money to the consumers of electricity, though saving money is itself a worthy objective.

These considerations are of importance to the mechanical-engineering profession because that profession will play one of the major roles in the development of nuclear reactors and associated heat-power equipment. As atomic power takes its place in our economy alongside power from coal, oil, gas, and water, many mechanical engineers of diverse specialties in both equipment manufacture and plant operation will be involved. Therefore it is appropriate to review the design problems and examine the kinds of work which now face engineers.

Any attempt at a complete detailed examination of the multitude of problems in a system of atomic-power facilities is obviously inappropriate. Hence, this paper includes only (*a*) a brief sketch of some problems in one possible system; (*b*) an explanation of a controlled nuclear chain reaction to help introduce the problems of the nuclear reactor; (*c*) a more detailed examination of some problems in the reactor; and (*d*) in conclusion some comments about growth of atomic power.

SYSTEM OF ATOMIC-POWER FACILITIES

A relatively simple possible arrangement of the minimum necessary kinds of facilities to provide atomic power from both government-controlled facilities and private plants is shown in Fig. 1.[2]

Mine. The first facility is obviously the mine for natural fuel, uranium, containing 0.7 per cent U^{235} and 99.3 per cent U^{238}. The mine is also the source of fertile materials or "source materials," as defined by the Atomic Energy Act of 1946. Uranium U^{238} and thorium Th^{232} are "fertile" in the sense that from them can be produced Pu^{239} and U^{233}, as explained by Doctor Nier.[1] The location of rich ore deposits of source material is certainly important and particularly so are those of uranium, the source of the only important natural fissionable isotope known, U^{235}.

Metal-Refining and Fabrication. The problem of producing suitably pure metallic uranium was solved during the war well enough to permit successful operation of the Hanford Engineer Works. This does not mean that major reductions in cost or improvement in process or product are not possible. Certainly, if atomic power is to be competitive, source-material costs are important. In the event that the future shows rich ore deposits to be insufficient, considered likely by some writers in reference (1), then we are faced with the more difficult problem of economic mining and refining the widespread medium- and low-grade ores. This problem is considered susceptible of solution by the writers in reference (1). In these refining operations the reduction of impurities which absorb neutrons may be a difficult but important problem. Much remains to be learned of the metallurgy of uranium and thorium before the forming and fabrication of elements of the nuclear reactor can be accomplished with the ease and flexibility needed to permit optimum designs.

Primary Pile. In Fig. 1 source materials are shown being charged into the next basic facility, the "primary pile" or primary nuclear reactor. The concept of "primary" and "secondary" piles has been developed in negotiations with the United Nations (3, 4). Primary piles contain source materials and produce new fissionable material; therefore it is expected

[1] The nuclear reaction which produces the two synthetic or artificial fissionable materials U^{233} and Pu^{239} is explained in a companion paper, by Dr. A. O. C. Nier, "Atomic-Power Engineering—Some Nuclear Problems," which appears on page 728 of this issue.

Contributed by the Power Division and Nuclear Energy Application Committee and presented at the Semi-Annual Meeting, Chicago, Ill., June 15–19, 1947, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[2] This diagram is quite similar to one published in reference (1).[3] This report is highly recommended and it discusses in detail many significant aspects of such a system briefed in this paper.

[3] Numbers in parentheses refer to the Bibliography at the end of the paper.

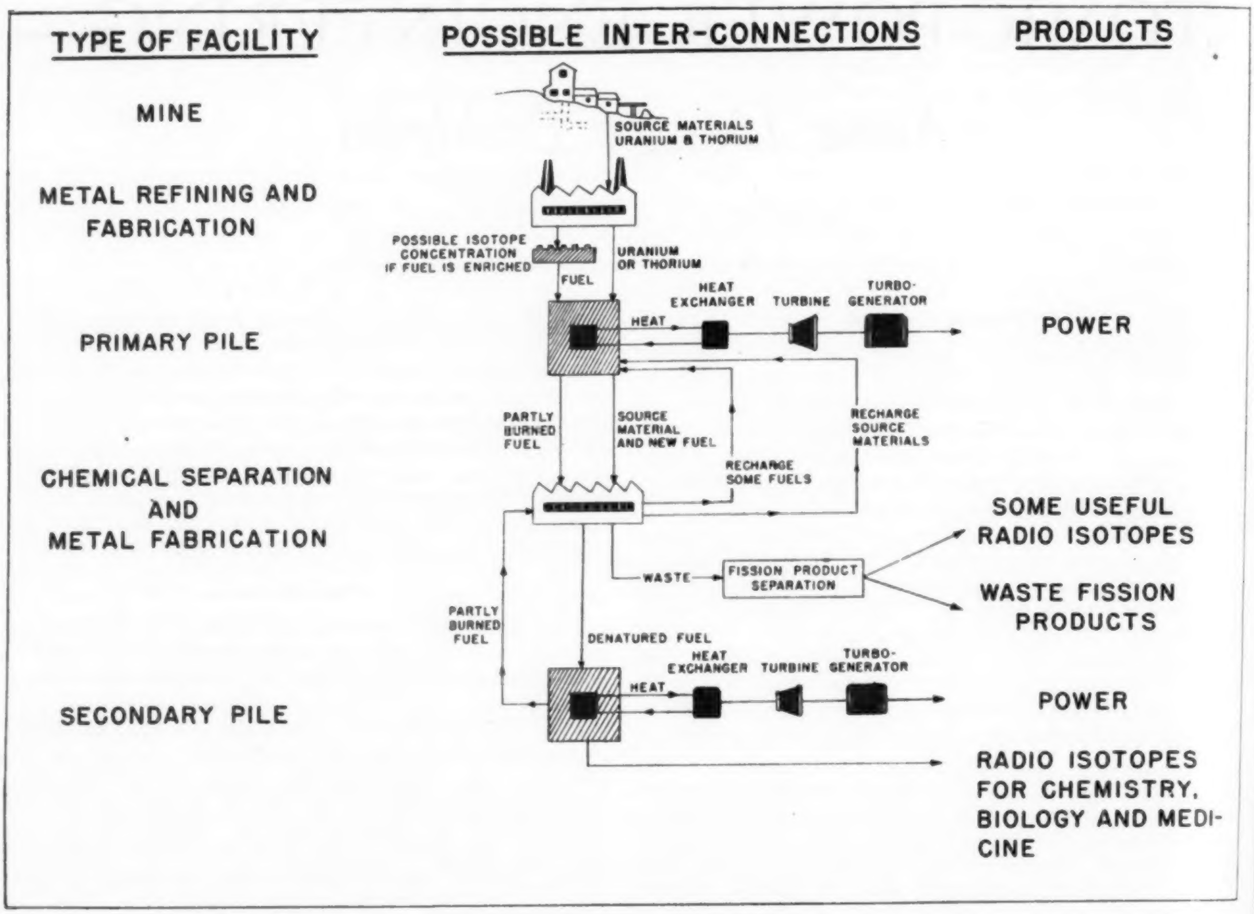

FIG. 1 ATOMIC-POWER FACILITIES

that they may be under control of the government or of an international authority. Secondary piles do not, and it is expected that they may be privately operated, possibly with inspection.

It is possible that some primary nuclear reactors may use fuel enriched in U^{235}, so in Fig. 1 an isotope-concentration plant is shown which may or may not be required in the channel of fuel charged to the primary reactor.

Design problems of the reactors are discussed in later sections. In this system outline the interconnections should be noted. It is likely that fuel will be discharged before it is entirely burned. Obvious reasons are reduction in pile reactivity because of burn-out of fuel, economic balance, and the like. The remaining fuel should be reclaimed in chemical-separation plant.

Discharged also is source material containing some new fuel which has been manufactured in the nuclear reactor. The new fuel must be separated in the chemical-separation plant and put in a suitable form for use.

Chemical Separation and Metal Fabrication. Referring again to Fig. 1, there are at least four significant types of channels for the output from the chemical separations plant, as follows:

1 Fuel recharged to the same or a similar primary reactor, including possibly both reclaimed (unburned) fuel and new fuel.

2 Source material recharged into primary reactors after new fuel has been stripped.

3 Denatured fuel charged into secondary reactors.[4] (Note by definition of a secondary pile, source materials cannot be charged.)

4 Wastes, including radioactive fission products which have been stripped from all useful outputs in sufficient degree so that the useful products can be successfully processed.

The design of facilities and equipment for handling the materials discharged from the reactor, with adequate protection for workmen's health, is much more difficult than the handling of new materials. The partly consumed fuel contains radioactive fission products which have alpha, beta, and gamma activities of very high level, equivalent to pounds, perhaps a ton, of radium, depending upon the scale of operations. Some of the most intense activity comes from radio-isotopes which decay quickly (have short "half-lives"). It may be desirable to arrange storage facilities to hold up the discharged material for some time, allowing the radioactivity to decrease, which diminishes the difficulty of handling in later processes. While a separate discharge of source material may not contain the considerable quantity of fission products in the consumed fuel, there will probably be some because of fission of some of the new-born fuel. The problem of handling source material differs only in degree.

These "hot" (in a radioactive sense) materials must be transported to the chemical-separation areas, requiring specially designed vehicles or conveyers. Remote-control loading and unloading equipment is needed. Precautions against loss or accidental disbursement of such material in transit are obvious necessities.

In the chemical-separation plant, the design of a fully remote-

[4] Note that denaturing simply amounts to adding to the fissionable isotope an amount of some other nonfissionable isotope of the same element, so that extraction of pure fissionable isotope for illegal military purposes would be difficult and easy to detect.

controlled process plant with means for remote-controlled repair, replacement, or modification of equipment, obviously involves a great deal of ingenuity and good engineering. Such a process may involve many of the usual stages of a chemical plant, i.e., dissolving, precipitating, filtering, centrifuging, skimming, mixing, and the like. Equipment must be designed so each stage can receive process material and reagents, carry through its operations, and discharge the results, all by remote control.

The efficiency of the chemical-separation plant may have a profound effect on the economy of the whole operation. To use a simple academic example, suppose plutonium is the kind of fuel both consumed and produced in some primary reactor. Also, suppose that the fuel is discharged and reclaimed after burning 10 per cent. A loss of 5 per cent in chemical separation of the 90 per cent unburned fuel would then amount to a loss of 45 per cent of the fuel burned each cycle. In a continuous cycle this amounts to a loss of 30 per cent of all fuel charged. This example also highlights the related importance of designing the pile and fuel to permit a maximum percentage of fuel consumption before discharge.

The chemical-separation-process designer is faced with many auxiliary problems. Reagents may become contaminated with fission products either as a normal part of the process or by accident in the process. Fission-product wastes must be disposed of in a safe fashion. If they are to be stored, the volume of vehicle must be kept to a minimum. If they are to be shipped elsewhere, even more stringent requirements are placed upon concentration. Some of the fission products are gases. These must be handled and disposed, avoiding release in dangerous concentrations.

Secondary Pile. The design problems of the secondary reactor in Fig. 1 are similar to those of the primary reactor, and the charging and discharging problems are similar. If fuel is only partly burned, it must also be processed as shown. A new output, useful radioisotopes, is shown. Of course, these could also be produced in a primary reactor. These are distinct from any useful portion of the fission products and are produced by inserting a "parent" material such as a compound of nitrogen $_7N^{14}$ in the neutron flux which produces radioactive carbon $_6C^{14}$ by a neutron-in, proton-out reaction. The great importance of such radioisotopes in medicine, biology, and chemistry is well recognized. The significant relation of their production to the nuclear reactor and to atomic power has been suggested in the introduction to this paper.

Power Cycle. One type of channel, shown in Fig. 1, remains to be discussed, the production of electric power from heat liberated in the reactor. This has been well covered in references (5, 6) and others. A likely system for land-based electric power plants is (*a*) a liquid-metal primary heat-transfer fluid which will be radioactive; (*b*) a heat exchanger to boil water to steam which will not be radioactive; (*c*) a steam-turbine generator set of standard high-temperature practice comparable with contemporary steam turbines transforming heat from other fuels; and (*d*) the normal electric-power transmission and distribution facilities.

THE NUCLEAR REACTOR

In order to integrate the many engineering problems of a nuclear reactor, the function of each basic part in the nuclear chain reaction is outlined first. In Doctor Nier's paper,[1] the nuclear properties of elements are described. In this description the function of each element in causing the controlled release of nuclear energy and in transporting and transforming this energy for use is emphasized.

Analogous Chemical Chain Reaction. Some analogous chemical chain reactions have been discussed more completely by Doctor Kingdon (2). Interesting as an introduction to the "chain" concept is the explosive decomposition of the relatively unstable, loosely bound, ammonium nitrate NH_4NO_3 into the simpler, more stable, more tightly bound molecules, N, O, and H_2O. Here the energy released comes from the change in binding energy of the molecules with presumably an extremely slight loss in mass. In the decomposition (fission) of the relatively unstable, loosely bound uranium U^{235} nucleus into two fragments, which eventually become nuclei of more stable, more tightly bound elements in the middle of the periodic table, there is a change in the binding energy which adds up to a loss of one-thousandth of the mass of the uranium. Since mass converted to energy gives 11,000,000,000 kwhr per lb of mass converted, this reaction gives 11,000,000 kwhr per lb of uranium fissioned. But this energy per pound of nuclear fuel is about 3,000,000 times the energy released per pound of a chemical fuel.

In the NH_4NO_3 decomposition, heat was the means of propagating the chain. In U^{235} neutrons are the means.

To propagate the NH_4NO_3 chain, one requires enough material to capture the heat of reaction from the first particle ignited for more NH_4NO_3 to be heated to ignition temperature, so it will continue to burn in a chain. If heat is lost outside the body of material without enough being captured, the fire stops. In U^{235} one must also have a "critical mass" of material to capture enough neutrons for fission before they are lost outside the reactor, for the chain to propagate itself.

In NH_4NO_3 one must have a favorable arrangement to transmit heat from one particle to another; one cannot disperse a few particles of explosive in a pile of sand and make it explode. In U^{235}, as Doctor Nier has shown, the amount of neutron-absorbing material in the reactor is very important and is generally detrimental to neutron economy. In nuclear reactors, however, neutron absorbers are sometimes used to slow or stop the reaction, much as if—by analogy—one threw sand into a burning pile of NH_4NO_3 to quench it.

Controlled Nuclear Chain Reaction. In Fig. 2 is shown a schematic arrangement[5] of the following:

1 Uranium fuel, containing U^{235} (fissionable material) and U^{238} (fertile material for production of Pu^{239}) in arbitrary proportions.

2 Moderator for slowing down neutrons.

3 Reflector for conserving neutrons.

4 Shield for protecting power-plant personnel.

5 Heat-transfer fluid for transporting the heat energy out of the nuclear reactor.

6 Control rod for varying the reactivity of the reactor and the power level.

In considering the chain reaction, it is convenient to analyze what happens in one generation of fissions. A generation may be described as the average length of time between when a neutron is liberated at fission and when it enters a nucleus of U^{235} to cause another fission. This length of time of average life of a neutron will be sensibly constant in any one design of nuclear reactor without regard to the power level. Therefore if the reactor is operating at constant power level, then the number of fissions in one generation is exactly equal to the number of fissions in the succeeding generations, as long as the power level remains constant.

In Fig. 2 are shown four fissions occurring during one generation, and, for simplicity, it is assumed that they all occur at the start of the generation and all in the upper fuel bar. Between

[5] While this schematic arrangement illustrates the principles of some nuclear reactors including the Hanford reactors, it is academic in the sense that in no way does it represent the physical proportions or numbers of any actual nuclear reactor past or future. This schematic diagram and a similar description of the reaction have been published by Doctor Kingdon (2).

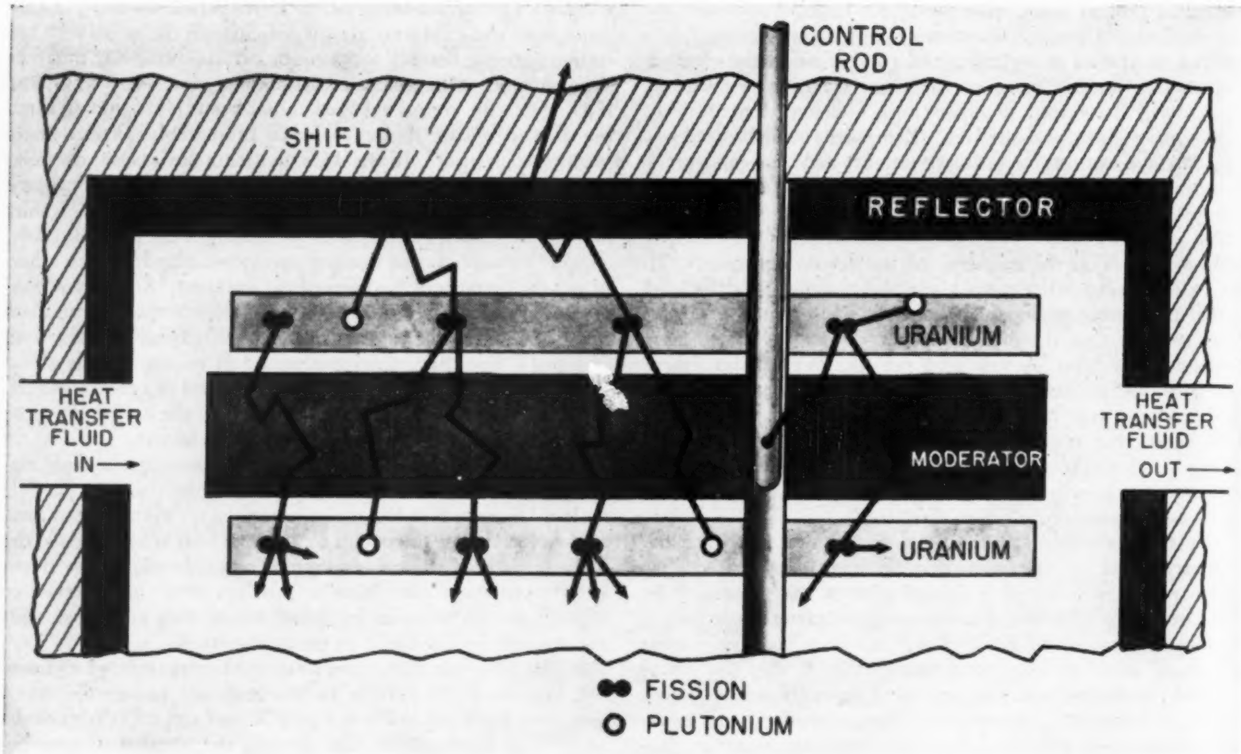

FIG. 2 NUCLEAR-ENERGY HEAT GENERATOR

1 and 3 neutrons are liberated by each fission, so 10 neutrons are shown being liberated by the four fissions. As described by Doctor Nier,[1] the probability that a slow or thermal neutron will cause fission in U^{235} is very much greater than the probability that a fast neutron will cause fission. In other words, the U^{235} fission cross section is much larger at low than at high neutron energies. Therefore in many types of reactors, a moderator, whose function is to slow down neutrons, is placed around a fuel rod in such an amount that most of the neutrons will be slowed down to thermal energies before they have an opportunity to cause fission in a bar of fuel. Recalling the chemical analogy, this is simply one way of getting a "favorable arrangement." Doctor Nier's paper[1] explains the slowing-down mechanism and shows that some of the low-mass-number elements are most effective.

At constant power level, exactly 4 neutrons from one generation of fissions must cause exactly four fissions in the next generation. Therefore in the diagram are shown 4 neutrons passing through the moderator where their direction is changed and energy reduced by collisions with nuclei of the moderator before they enter the lower fuel bar, where these 4 neutrons produce four fissions which in turn produce another 10 neutrons for the succeeding generation.

In this academic example, 6 neutrons are not required for fission. As many as possible of these extra neutrons should be used for productive purposes. One possible use is for the production of new fuel. Some U^{238} has been included in the U^{235} fuel bar, and the pile has been arbitrarily arranged with a proportion of U^{238} to U^{235} so that the probability that a slow neutron will be captured by U^{238} to form plutonium is equal to the probability that a slow neutron will be captured by U^{235} to cause fission. Therefore there are four new nuclei of plutonium formed in this generation by 4 neutrons slowed down in the moderator or reflector.

In any practical reactor there must be an allowance for loss of some neutrons. In Fig. 2 is shown one neutron escaping through the reflector into the shield where it is slowed down, then absorbed. It is lost in so far as any productive use is concerned.

If there is to be a means for intentional acceleration or deceleration of this chain reaction, positive means must be available to change the reproduction of the fissions in each generation from the 1-for-1 basis shown to a different reproduction ratio. Since the neutron flux is the medium of propagating the reaction, control of it can change the reproduction ratio of fissions. To accomplish this, a control rod which consists of a good neutron absorber such as cadmium or boron, is used. This control rod is shown extended into the pile just far enough to capture one of the 10 neutrons. If the control rod were in this same position but the power level happened to be greater or less than that shown, the control rod would still capture 10 per cent of the neutrons, thus maintaining the 1-for-1 reproduction even though the fission intensity was different. To accelerate the action simply withdraw the control rod and permit the neutron which it had previously absorbed to cause an additional fission. In this example it was arbitrarily assumed that the design and the ratio of U^{235} to U^{238} is such that the probabilities of a neutron-producing fission or making plutonium are equal. Therefore this change would, on the average, beget four and one-half fissions in the next generation for four in the first. The power level increases in a geometric progression. Since the period of a generation is constant, the acceleration is exponential with time and will continue indefinitely until something changes the ratio of reproduction. When the desired higher power level is reached, the control rod is returned to approximately its previous position or where it captures 10 per cent of the neutrons. Then the reactor is operating at a new constant but higher power level. A reverse procedure is used to reduce power level.

In addition to accomplishing the dynamic control of the reactor for purposes of applying it to power systems, sufficient margin of control must be provided (*a*) to adjust for relatively slow changes in reactivity (reproduction ratio) due to burnout of the fuel; (*b*) to provide a margin of reactivity to offset the accumulation of fission products (some of which may be effective absorbers of neutrons); and (*c*) to provide for variations in reactivity due to thermal expansion or contraction of active or structural parts of the reactor.

Note that the tenth neutron used in control completed the accounting of all neutrons in the generation. Omitted from the diagram for simplicity were losses by absorption in structural parts of the pile, use of neutrons to produce radioactive isotopes for sale, neutrons causing fission of plutonium, and other possible reactions.

Having accomplished a controlled chain reaction, the heat liberated must be extracted as rapidly as it is produced in order to maintain the temperature of fuel and structural parts at limits established by the materials. About 80 per cent of the energy appears immediately at fission as kinetic energy of the two fission fragments which move in opposite directions at high velocity. In this example the fuel is part of a solid fuel bar so that these fragments collide immediately with adjacent atoms. Actually, the fragments move only a few thousandths of an inch before the kinetic energy is given up to adjacent atoms and appears there as increased atomic or molecular vibration which is heat. Therefore the majority of the fission energy is available only as heat energy and at the point of fission. The heat must then flow out of the fuel bar through any barrier or "canning material" which is used to prevent the fission products from contaminating the heat-transfer fluid and be transferred to the fluid.

The remaining 20 per cent of the energy is approximately 2.5 per cent in kinetic energy of neutrons released, 2 per cent in prompt gamma rays, 4.5 per cent in binding energy released when neutrons are absorbed, and 10 per cent in radiations from unstable fission-fragment nuclei as they decay at various rates to stable isotopes. Most of this energy appears sometime as heat in various parts of the reactor and shield.

POWER NUCLEAR-REACTOR DESIGN PROBLEMS

Chain Reaction. Some of the nuclear-physics requirements to produce a favorable arrangement of enough fissionable material to get a potentially greater reproduction factor than 1.0 (supercritical mass) were discussed in the previous section and by Doctor Nier.[1] Here is where the design engineer must compromise parasitic losses of neutrons by absorption in materials he puts in the reactor with the desired structural or other properties of the materials. Throughout the later discussions of structure, heat-transfer fluid, and the like, the requirement of low absorption is ever-present. This factor, more than almost any other, forces the design engineer to examine the possible applications of a much wider variety of materials and alloys than he would have to do in any usual heat-power equipment. He cannot afford to overlook the possibilities of relatively unknown members of the periodic table.

In addition to materials compromise between absorption and desired physical properties, he must compromise the most favorable theoretical arrangements for supercritical reactivity with such practical items as the following:

1 Flat surfaces compared to cylindrical or spherical surfaces.

2 Practical lattice arrangement of fuel bars or shapes to permit loading and unloading, opposed to an ideal arrangement for neutron economy.

3 Space and ducts for heat-transfer fluid reducing neutron economy.

4 Space and arrangement of control rods compromised with the uneven distribution of neutron flux which they may produce, interference with fuel bars, and the like.

All such compromises will affect the economy of neutrons and the investment in the "critical mass" of fissionable material put in the reactor, both of distinct economic significance.

Heat Transfer. Here is perhaps one of the most challenging fields for engineering advance. The tremendous power densities and temperatures of the bomb have been produced. Power densities and temperatures can be produced in a power reactor as high as the heat-transfer and materials engineers can handle. Furthermore, some features of the problem are favorable. The heat can be made available in a solid material for conduction and transfer by forced convection to a fluid under controlled surface conditions. Compared to an ordinary fuel-combustion boiler with heat transfer from combustion gases, good design should permit much higher heat fluxes with resultant economy in size and cost.

Any material in the reactor is subjected to a neutron flux of great density. Neutrons are sufficiently potent projectiles that they can cause many effects besides fission and transmutation which have been discussed. The designer must examine any material in the pile for its "radiation stability." Changes may occur in structural properties such as elastic limit, elongation, and the like; thermal and electrical conductivity; and—most important in fluids—chemical dissociation. As shown by Doctor Nier,[1] light nuclei are most effective in slowing down neutrons and these nuclei likewise recoil with highest velocity; consequently, one might expect that chemical compounds containing hydrogen, and to a lesser extent carbon, may be dissociated. The poor radiation stability of organic compounds rules out a large number of possible heat-transfer fluids. In general, pure elements will be most stable and, in particular, noble gases and liquid metals are favored. Water in addition to possible chemical dissociation has a great disadvantage in that it boils at unacceptable pressures and temperatures. It is unwise to allow a phase change in the reactor because of possible sudden changes in reactivity beyond the small permissible margin in control. Gas volumes and pressures necessary for high heat flux make liquid metals more favorable for high power density. Economy in recirculating-pump power also favors liquid metals in closed cycles.

There are obviously a great many possible thermodynamic cycles. Also there are various applications such as aircraft, naval craft, mobile power plants, and the like. Many have factors decisive in the selection of the primary fluid. Gases, even with open-cycle gas turbines, possibly in jets or rockets, may be best on some of these. However, the path which land-based electric plants will probably follow seems fairly definite, i.e., liquid metal to steam, or perhaps a three-fluid system. In all probability each loop of the cycle will be closed for reasons of economy and radiation hazard.

Industry has had sufficient experience with mercury, a fairly difficult, chemically poisonous metal, to know that it can master the problems of handling liquid metals. This experience has also taught us that the problems may not be easy of solution.

Structural Problems. A fundamental factor entering almost every detail of reactor design is reliability for the expected life of the reactor. Almost any structural part will become radioactive in some degree after the pile has operated at significant power for some time. Not only will transmutations occur in the basic material but also in its impurities. Consequently, essentially no parts, mechanisms, or instruments from within the pile can be handled directly for repair, replacement, or modification. Unless the designer has made provision for replacement of some part using special remote-control tools and providing adequate shields for the operators, a failure of some part may well mean the end of that reactor.

The possible life of a reactor may be very long indeed. If adequate attention is paid to the "radiation stability" of materials, there is no part which is basically short-lived. The shield does not become saturated with products of neutron absorption, nor do other structural parts in degree sufficient to limit their life seriously. However, the degree of reliability required is very great.

Some of the significant structural or mechanical design problems arise in providing loading and unloading mechanisms for fuel packages and source-material packages. Both, when in the reactor, are intimately associated with the heat-transfer fluid. If high rates of heat transfer are provided, and they should be, the packages will doubtless be in direct contact with the fluid. This requires opening fluid channels and extracting fuel packages without loss of radioactive heat-transfer fluid, or exposure of operators to radiation from the pile or from "hot" discharged fuel. In a high-performance heat-transfer system, maintenance of extreme purity of the heat-transfer fluid may require that air, dirt, and the like be prevented from entering the fluid channels during refueling.

Obviously, it will be desirable to design to refuel major power plants without interrupting the continuous output of power. This will involve some major problems. Not only must the loss or contamination of the fluid be prevented but its continuity of flow must be maintained. Furthermore, refueling cannot be allowed suddenly to change the reactivity enough to exceed the narrow control limits discussed under *Control*. Negligible sudden changes in reactivity may require that the fuel and source-material charge be divided into a great many small elements in many channels.

Such subdivision may also be dictated by the fact that fuel at different locations may be exposed to different intensities of neutron flux. If so, the rate of consumption will vary. The same may be true of the formation of new fuel in different locations in the source material. Therefore the charging and discharging mechanism should be capable of selecting and loading different channels with different frequency. Furthermore, such patterns should be flexible to provide for changes over years of operation dictated by variations in cost and production of different fuels.

The discharge end of the refueling operation has its own special problems. All motions or actions must be accomplished essentially by remote control, including the sorting of different elements. The elements must be placed in suitable shielded devices for either storage or transportation. Obviously, some care must be exercised to avoid accumulating a supercritical mass of fissionable material. In such an operation the engineer should anticipate jams due to malfunction of valves, parts, damaged fuel elements, and the like, and prepare suitable remote-control devices for locating and clearing up such difficulties.

Control Problems. Some principles of control of the neutron flux have been outlined in the section "The Nuclear Reactor." The extreme simplification necessary for clarity in that section may in some ways be misleading. For example, a generation of four fissions was discussed. Actually, one hundred million billion fissions occur to release 1 kwhr of energy. The period of a generation was discussed. While this obviously varies a great deal, depending upon pile design, the period or mean life of slow neutrons in a reactor may be of the order of 0.002 sec, as calculated in reference (7) for the reactor chosen there for illustration. The significance of short time between generations in control is very great. In the same reference, the speed of multiplication of the illustrated pile is calculated for a reproduction ratio of 1.252, which corresponds in that case to a pile of infinite dimensions, no losses of neutrons at a boundary. The power level would increase exponentially with a period of 0.0085 sec or increase power by a factor of ϵ in that short time. Such a dramatic and extreme calculation is important here only to high light an important factor in control, i.e., delayed neutrons as distinct from prompt neutrons liberated instantaneously at fission.

Some 99.4 per cent of fission neutrons are prompt. If all were prompt, short time constants, such as calculated in the preceding paragraph, would prevail, and whether or not a reaction could be controlled would be very doubtful. However, 0.61 per cent of the neutrons are delayed from 0.61 sec to 80 sec (7). If then, the reproduction factor is never allowed to exceed 1.006, the period of the reaction is determined not by the lifetime of a prompt neutron but by that of the delayed neutrons. In the terms of the description in the section, "The Nuclear Reactor," then, one is actually interested in reproduction of, say, 1.0001 for 1.0000 each generation, instead of $4^1/_2$ for 4. Because of the sequence of events in one generation, it is clear that the increase in the next generation does not occur until the delayed neutrons corresponding to the excess in reproduction have been liberated and absorbed. Therefore, time constants which the engineer can handle with a practical design of control are possible.

One purpose of detailing this factor in control is again to high light the importance of other problems, such as fuel-loading, structural design, heat transfer, and others. Essentially no shift in position, expansion, cavitation, or boiling of the heat-transfer fluid, and the like can be allowed suddenly to change the reactivity by as much as 0.6 per cent.

These problems can all be solved. Obviously, they have been successfully solved on the reactors at Argonne, Clinton, and Hanford. There is no reason to believe that rates of acceleration and deceleration comparable to modern steam-boiler practice cannot be obtained with safety and reliability, but thorough and precise engineering is required.

Summary of Design Problems. The foregoing discussion is illustrative rather than complete. There are many other design factors, such as corrosion, which have been omitted. There are major components, such as the shield, which have not been covered. However, it is important in this introductory discussion to indicate some of the classes of problems characteristic of this field, some new to the engineering profession:

1 Radiation stability of materials.
2 Nuclear properties of materials, fission, scattering, slowing down, absorption.
3 Radiation protection for personnel.
4 Extreme reliability.

CONCLUSION

In concluding it may be appropriate for the author to offer some estimates of timing in the development and expansion of atomic power for use as electricity by industry and consumers.

The first main problem is to produce a high-temperature, experimental, controlled nuclear reactor, with advanced design and materials so it is a major step toward a large-scale power reactor. The author estimates that such an experimental reactor may be developed, designed, and built, and that it may produce electric power in 3 to 6 years. The main limitations in this stage are technical problems. The outline of problems in this paper should make it apparent that a much earlier achievement of stated objectives is not feasible.

The limit on the next few steps to a prototype of a practical large-scale power reactor is also technical. The author estimates that such a prototype may produce, say, 100,000 kw of electricity in from 7 to 15 years' time.

The prototype of a plant suitable for installation and operation at various sites delivering large-scale electric power from atomic energy is the start of another phase where factors other than technical may control growth. However, technical im-

provement will have to continue to reduce the cost of atomic power so it will expand naturally in our national economy. Therefore it is appropriate to consider the economics for a moment before proceeding with the analysis of timing.

On the much debated question of economy, the author's opinion is simply that there appears to be no technical problem which seems likely to prevent atomic energy from becoming competitive with other fuels to the considerable benefit of the national economy. Whether it will or will not, however, depends upon many factors, such as, intensity of technical effort, technical modifications which may be found necessary to implement national or world security, and existence or absence of a workable international control of atomic energy. With such major questions as these yet to be resolved, there is little to be gained by speculating on such economic considerations as investment, fuel costs, and the like. It is well to recognize that atomic-power plants in 20 years will probably bear little resemblance to our current technology or even our expectations. Therefore a forecast of investment, operating, and fuel costs, to be realized 20 years hence, is likely to be more misleading than useful.

If the growth of atomic power is controlled by economic factors as distinct from matters of national policy or security, its advent cannot be other than orderly. It will fit gradually and naturally into the pattern alongside coal, oil, gas, and water, increasing first in those areas which favor it economically. There is no basis for predicting any sudden dislocation or wiping out of any particular competitive source of energy.

Returning to the consideration of timing, factors additional to cost and technology affecting growth after a prototype are:

1 Expansion of atomic-power-plant manufacturing facilities.

2 Manufacture of ever-increasing quantities of atomic-power equipment. (The magnitude of this job is doubtless greater than the job of manufacturing steam boilers and turbines today.)

3 Installation and integration of plants by electric-utility operators in their power networks.

4 Training and expansion of technical and specialized personnel in both manufacturing and operating companies such as engineers, technicians, and health physicists for radiation safety control.

Similar factors to these were inherent in the growth of the present fuel-burning electric-power industry. Therefore Fig. 3, which shows this growth, is worthy of examination. The curve starts at 1890, with about 100,000 kw being generated. This is comparable to the "prototype" atomic plant, estimated for about 10 years from now. By 1900 there were 2,000,000 kw; by 1920 the total was 10,000,000 kw; and now 55 years from the prototype, there are 35,000,000 kw (1945). A parallel relation to atomic-power expansion cannot be drawn too precisely. However, it may be safe to predict that power, comparable to our present capacity or a major part of it, may be achieved in 50 years (40 years from prototype). This is faster growth than the history of the steam-electric industry. It also seems clear that such a scale cannot be accomplished as soon as 20 years from now (10 years from prototype). To build, install, and operate an atomic-power industry comparable to our present steam-electric industry in 10 years would indeed mean taking maximum advantage of our great industrial capacity.

The potential benefits of atomic power are so attractive that research and development programs should proceed. As this work progresses and firm answers are obtained, it may well be desirable to push and accelerate a program designed to bring atomic power to fruition at as early a time as practicable. In any case, until some fact or condition points in the opposite

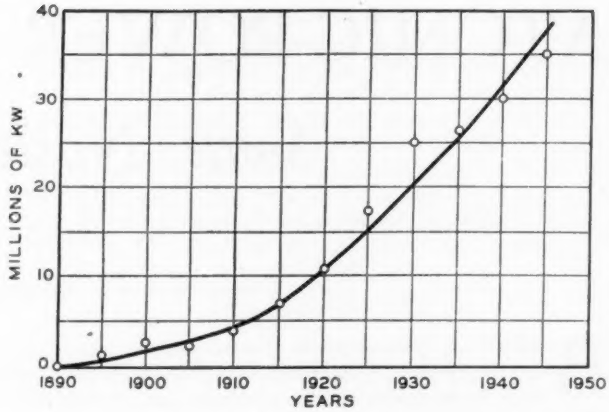

FIG. 3 INSTALLED CAPACITY OF PLANTS GENERATING ELECTRICAL POWER FROM FUEL IN THE UNITED STATES

direction, it is appropriate to proceed with a positive, vigorous program. It is just as important to have progress in the early stages when technical problems are being mastered the first time as in the later stages. A year is a year any place on the time scale. Because many engineers and in increasing numbers will be required by all elements in the system of atomic-power facilities, it is not too early for them to begin their education in this new, facinating, and potentially productive field.

In addition to this strong economic reason, there are two more compelling motives for emphasis on engineering and research in nuclear energy. One, of course, is military security. Pending the resolution of the formidable political problems involved in obtaining a demonstrated workable international control, progress in atomic energy is vital to the American people. The second motive has been so effectively stated by Mr. Lilienthal (8) that we engineers cannot avoid the challenge:

"To me, atomic energy is more than something that in an indeterminate period will light electric bulbs or provide radioactive materials for our doctors . . . I don't underestimate these coming advances . . . But we will completely miss the point, and the whole effort will slacken and lose its drive if we think of it only in terms of immediate, practical gadgets and benefits. For as I see it, in the atomic adventure we sight one of those great mountain peaks of history, a towering symbol of one of the faiths that makes man civilized, the faith in knowledge . . .

"The people throughout the whole of American society must realize that we have in the unfolding knowledge of the atom the means for making our time one of the two or three most vital, most intense, and stimulating periods of all history . . ."

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ATOMIC-POWER ENGINEERING—

Some Nuclear Problems

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BEFORE any great scientific discovery can be put to everyday use, there are formidable engineering problems which must be overcome. Although the fundamental principle of the electric generator was discovered in 1831, over half a century passed before electricity found widespread application. New and better ways had to be found for making and insulating copper wire. Magnetic materials had to be studied and special steels developed, to make practical the present highly efficient generator and motor. The electric-light bulb had to be invented and perfected. The steam turbine had to be developed. These and countless other problems had to be solved by engineers and scientists working together in order to bring the electrical industry to its present state of maturity.

Before atomic energy can be used for practical power production, there are many bridges which must yet be crossed. Because of the complexity of the problems, close co-operation between the scientist and engineer will be required in order that each will understand the difficulties of the other.

Although the pressure exerted by the steam in a steam engine is produced by the impact of countless molecules on the retaining walls, power engineers have never had to concern themselves much with the nature of collisions between gas molecules, the velocities of molecules, or other details of molecular phenomena studied in detail by physicists and physical chemists. An empirical knowledge of the gross properties of matter has usually been sufficient.

In the atomic engine, as in the steam engine, billions and billions of atoms are involved in the production of useful amounts of work. However, unlike the steam engine where all the atoms of the working substance are undergoing the same processes, the atomic engine has many different processes taking place within it simultaneously, some of which compete with one another for atoms. Thus to understand the performance of an atomic engine one must have a rather detailed knowledge of the behavior of individual atoms.

In order to understand the behavior of atomic-energy devices, it is necessary that one appreciate some of the nuclear-physics problems involved. This appreciation can be gained, the author hopes, by employing a point of view which will be presented in this paper.

ESSENTIAL PARTS OF THE ATOMIC-ENERGY ENGINE

Let us consider the essential parts of an atomic-energy engine of the general sort that has been proposed. In Fig. 1 is shown a schematic drawing of such an engine. Here the pieces of uranium or other fissionable substance are shown surrounded by suitable retaining jackets. In addition to the fissionable substance there must be a moderator, a substance which will slow down the fast neutrons produced in the fission process so that they will be useful in producing more fissions. In operation a

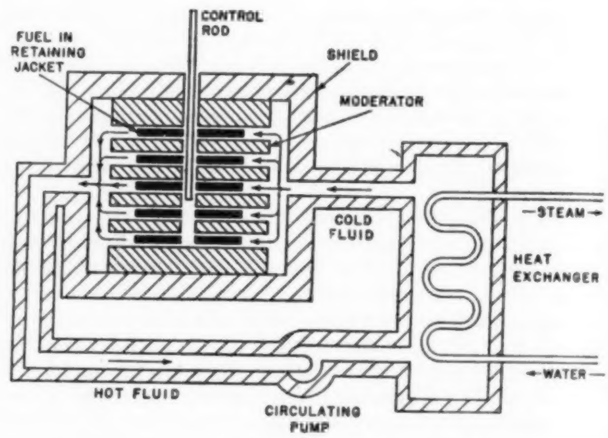

FIG. 1 SCHEMATIC ARRANGEMENT OF ATOMIC REACTOR

neutron strikes a uranium 235 nucleus, blows it apart into two heavy fragments, each having about one half the mass of the original atom; loose neutrons are also produced in the process. If the device is properly constructed, many of the neutrons produced will in turn strike other uranium atoms, blow them apart, and produce more neutrons and more energetic atom fragments. In other words, if conditions are properly arranged, we will have a chain reaction; the device will itself furnish the neutrons needed to keep the reaction going and in the process act as a source of energy through the conversion of stored atomic energy into kinetic energy of the fragments formed in the fission process. The kinetic energy is converted into heat which may be removed for utilization by circulating a suitable fluid around the slugs of fissionable material. By means of a heat exchanger, steam can then be produced for operation of conventional power units. The particular arrangement presented here is perhaps already obsolete. However, it contains so many of the basic principles involved that it is well worth examining further so that greater insight may be gained into the problem which must be solved.

Let us examine some of the requirements for materials of construction. It is noted that the cans housing the fissionable materials must not absorb too many neutrons. The same may be said of the cooling fluid and the moderator. On the other hand, the rods for controlling the neutron density should be good absorbers, as should the shield surrounding the reactor and heat exchanger. The fuel itself must not absorb too many neutrons in nonprofitable processes and must contain sufficient active material so that, as the fission products build up and cause a parasitic loss of neutrons, there will be a sufficient excess production to make up for this loss.

Thus it is seen that the atomic-power engineer must not only concern himself with the ordinary properties of his building materials such as thermal conductivity and expansion, entropy,

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enthalpy, resistance to corrosion, and many others, but he must also be concerned with the nuclear properties of the materials. Is there any convenient way in which the nuclear properties may be expressed? Yes, there is, if it is noted that all the effects in an atomic-energy generation system are caused by the collisions of particles or rays with materials. This suggests that the nuclear properties may be described in terms of collision probabilities, or in terms of a quantity which is called the "cross section" of an atom. These are terms which are perhaps new to the engineer, but well known to the physicist.

"THE CROSS SECTION OF AN ATOM"

If a beam of atomic particles is projected against a block of material, some will make collisions with the atoms in the block, others will pass through as shown in Fig. 2. Here are shown 16 particles striking the front of the block. In the first element of thickness one half or 8 have made collisions, the remainder passing on into the next element where one half or 4 of these make collisions leaving 2 to pass into the next element with only 1 emerging from the block without having suffered a collision. Had the cross sections of the circles (atoms) been

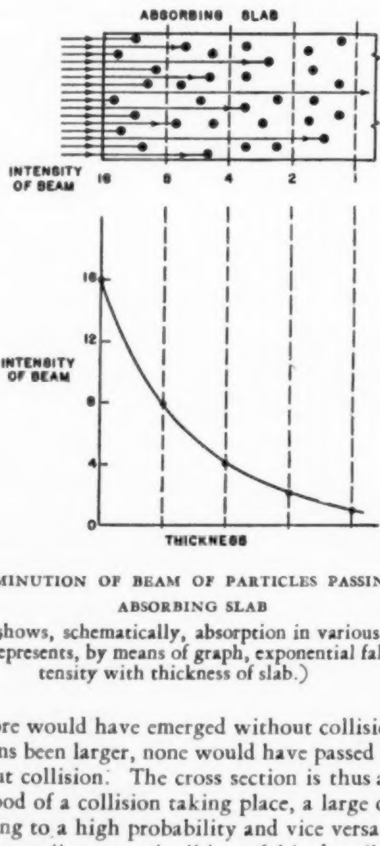

FIG. 2 DIMINUTION OF BEAM OF PARTICLES PASSING THROUGH ABSORBING SLAB

(Upper part shows, schematically, absorption in various parts of slab. Lower part represents, by means of graph, exponential falling off of intensity with thickness of slab.)

smaller, more would have emerged without collision; had the cross sections been larger, none would have passed through the slab without collision. The cross section is thus a measure of the likelihood of a collision taking place, a large cross section corresponding to a high probability and vice versa.

Now the term "cross section" is useful in describing a whole host of phenomena. For example, it is stated that uranium 235 has a certain fission cross section. By this, reference is made to the probability that when a beam of neutrons is sent through a thin slab of material, a collision will occur which results in fission. Or, one may refer to the elastic collision cross section of an atom by which is meant the probability of collision taking place without any loss of energy, as in the case of the collision of two perfect billiard balls. These are but two examples of the kinds of cross sections which atomic physicists discuss. As we shall see, there are others which it is useful to define.

Of what order of magnitude are atomic cross sections? In most cases atomic nuclei behave as if they had diameters of about 10^{-12} cm or cross-sectional areas of 10^{-24} cm^2. This number varies greatly from element to element and from process to process and for that matter with the speed and nature of the projectiles employed. Thus a statement of the value of the cross section has no meaning unless the exact process involved is also defined. Cross sections greater than 10^{-24} cm^2 are generally considered large. Thus we see some workers measuring cross sections in terms of "barns," the barn representing an area of 10^{-24} cm^2, the implication being that anything as large or larger than this is "big as a barn."

ATOMIC CROSS SECTION OF U^{235}

What are some of the atomic cross sections which should be of concern in atomic-power units? We should be interested in the fission cross section of our fissionable material. In what follows it will be assumed that U^{235} is being used. However, similar arguments will apply to other fissionable substances such as plutonium 239 and uranium 233. When a U^{235} nucleus undergoes fission, the neutrons released have a rather high energy. The fission cross section of U^{235} is relatively small for high-energy neutrons, but large for really slow neutrons in the thermal-energy range. Thus if one wishes to produce a chain reaction, it is to his advantage to slow down the neutrons. Neutrons may be slowed down by making elastic collisions with atomic nuclei. Thus a reactor should contain some substances with which the neutrons may collide. However, in making the collisions one must make sure that the neutrons are not lost in some absorption process. In other words, the slowing-down medium, technically called the "moderator," should have a high cross section for elastic collisions and a low cross section for capturing neutrons. In any event, it should be attempted to slow down the neutrons in as few collisions as possible, since then there will be a minimum of chance of losing them.

By the ordinary laws of mechanics, it can be shown that if an object is slowed down by letting it make an elastic collision with some stationary object, the greatest amount of energy is lost in a collision if the masses of the two objects are equal, in which case, one will lose 50 per cent of the energy per collision. This suggests immediately that hydrogen should be employed as a moderator, since the mass of the hydrogen atom is the same as that of the neutron. Thus if it is desired to slow down a 1,000,000-electron-volt neutron[2] to an energy of 0.1 electron-volt, about 20 collisions would be required. On the other hand, if one chose to lose this energy by allowing collisions with, let us say, carbon atoms which are 12 times as heavy as neutrons, one would lose only 14 per cent of the energy in a collision and would need about 123, or 6 times as many collisions. However, this is not the entire story, for the fact must be considered that there is a certain probability of absorption of neutrons in the slowing-down material. As a matter of fact, there are numerous elements for which the absorption cross section is much less than for hydrogen and hence these are better moderators in spite of their greater mass.

Creutz[3] has tabulated the relative elastic and absorption cross sections for a number of the light elements in order to demonstrate this effect. These data are presented in Table 1. The first column shows the fraction of energy lost by a neutron each time it makes an elastic collision with a nucleus of one of the elements listed. In the second column is shown a rough value for σ_s, the elastic scattering cross section in barns.

[2] The "electron-volt" is a unit of energy employed by physicists in describing atomic processes. It represents the amount of energy acquired by a single electron in falling through a difference of electrical potential of 1 volt. From an engineering point of view it is an extremely small unit, 8.3×10^{18} electron-volts being equivalent to 1 ft-lb of work.

[3] "Controls for the Chain-Reacting Pile," by E. C. Creutz, *Instruments*, vol. 20, February, 1947, pp. 139–140.

The product $f\sigma_s$ is thus a measure of the ease of slowing down a neutron by means of elastic collisions. In column 4 are shown rough values for σ_a, the absorption cross section in barns. The larger this quantity is the greater will be the chance of losing a neutron by absorption. Thus the ratio $f\sigma_s/\sigma_a$ can be considered as a figure of merit of the element as a slowing-down medium. We see, for example, that helium would be an excellent material to use, but since it is a gas, it would be hard to obtain a high density of atoms without the use of very high pressures. Ordinary hydrogen is not especially good. Heavy hydrogen, not listed, is much better. Lithium and boron, because they absorb neutrons so readily, are very poor substances to use as slowing-down media. On the other hand, beryllium and carbon are very good. Because of the availability of the latter in the form of graphite it was actually used in the early chain-reacting piles.

TABLE 1 RELATIVE ELASTIC AND ABSORPTION CROSS SECTIONS FOR SOME LIGHT ELEMENTS

	f	σ_s	$f\sigma_s$	σ_a	$f\sigma_s/\sigma_a$
Hydrogen	0.5	20	10	0.3	30
Helium	0.3	1.5	0.48	0	large
Lithium	0.25	6	1.5	60	0.02
Beryllium	0.22	6	1.3	0.007	185
Boron	0.16	6	0.96	700	0.001
Carbon	0.14	5	0.7	0.004	175

Table 1 is useful in other ways. It demonstrates the need for extremely pure materials of construction. For example, if carbon is used as a moderator, and if it contains only 10 ppm of boron as an impurity, as many neutrons will be absorbed by the boron as by the carbon itself.

UTILIZATION OF NEUTRONS IN A REACTION

The competition between profitable and nonprofitable utilization of neutrons is one with which we must contend throughout this problem. For example, when ordinary uranium is used as a fuel in a reactor, there are 139 times as many U^{238} as U^{235} atoms present. Now if the absorption cross section of U^{238} is plotted as a function of neutron energy, one finds that it has a sharp maximum, or resonance value at a neutron energy intermediate between that of the neutrons produced and the energy required for maximum fission of U^{235}. Thus in slowing down the neutrons there is a good chance of losing a large share of them as they pass through the resonance region. Fortunately, the effect may be minimized by proper geometrical arrangement of the uranium relative to the moderator. In the future, the utilization of uranium in which the U^{235} has been enriched will further reduce the importance of this factor.

It has just been mentioned that the resonance absorption by U^{238} diverted neutrons from accomplishing the main objective, namely, the fission of U^{235}. However, when one considers what happens as a result of the absorption process in this special case, it is realized that this is not a total loss. When a neutron is captured by U^{238} the following nuclear reactions take place

$$
{}_{92}U^{238} + {}_0n^1 \rightarrow {}_{92}U^{239} \rightarrow {}_{93}Np^{239} + {}_{-1}e^0
$$
$$
\searrow \; {}_{94}Pu^{239} + {}_{-1}e^0
$$

This nuclear equation is analogous to similar equations written down in chemistry to express the conservation of material in a chemical reaction. The subscript indicates the atomic number of the element involved and is numerically equal to the number of protons contained in the nucleus in question. Thus it also expresses the amount of electrical charge on the nucleus. The superscript indicates the atomic weight of the element, using the weight of a proton (hydrogen nucleus) as a unit. Since the weights of protons and neutrons are just the same and since nuclei contain only protons and neutrons, the superscript indicates the sum of the number of protons and neutrons contained in the nucleus in question.

Thus the first step in the reaction is one in which a neutron is absorbed to form a new uranium nucleus weighing 1 unit more than the starting nucleus. Next, the equation indicates that the new nucleus formed is unstable and disintegrates to form still another nucleus, neptunium 239. In the process a neutron is converted into an electron, indicated as ${}_{-1}e^0$. Finally ${}_{93}Np^{239}$, since it is unstable, decays to form plutonium 239, again through the conversion of a neutron into a proton.

It develops that Pu^{239} like U^{235} has the remarkable property that when struck by neutrons of the proper energy it too will undergo fission. Thus while U^{235} is being lost, Pu^{239} is being gained. Since only $^1/_{140}$ of the uranium atoms in nature are U^{235}, the economic consequence of the plutonium creation is seen. If things could be arranged so that for each U^{235} atom lost, one or more Pu^{239} atoms were created, one could soon dispense with the utilization of U^{235} and would instead "burn up" the 139-times-more-abundant U^{238}, instead of the rare and precious U^{235}. Even if this goal is never achieved, the production of some Pu^{239} will reduce the demand for U^{235}.

The same argument holds for the production of U^{233} from thorium. In this case the nuclear reactions involved are as follows

$$
{}_{90}Th^{232} + {}_0n^1 \rightarrow {}_{90}Th^{233} \rightarrow {}_{91}Pa^{233} + {}_{-1}e^0
$$
$$
\searrow \; {}_{92}U^{233} + {}_{-1}e^0
$$

If any neutrons over and above the minimum required to keep the chain going could be diverted into making U^{233}, again the drain would be lessened on the U^{235} stock and would be replaced by a drain on the much more abundant element thorium. These statements are pure conjectures. The practicality of the usefulness of these processes remains among the interesting problems of the future.

PRODUCTS OF ATOMIC FISSION

When an atomic fuel undergoes fission, elements near the middle of the atomic table are formed. For each atom of U-235 which is destroyed, two new lighter atoms are created. Some of these will have a low cross section for absorption of neutrons. Others will have larger values and will act as parasites in removing neutrons from the pile. Thus in any practical atomic "furnace" the waste products must be removed. In the Hanford plant the problem was solved by removing the canned uranium slugs at regular intervals, dissolving the contents by a laborious chemical process, and separating out the uranium and plutonium for further work. This might be a fairly straightforward operation were it not for the fact that the fission products are so strongly radioactive that all chemical manipulation has to be done in batch processes by remote control behind thick concrete shields. The replacement of the batch-handling by continuous methods should be a challenging problem to the engineer and would do much to lower the cost of atomic energy.

It has already been mentioned that different elements interact in different ways with neutrons. Consider for example the element cadmium. This element has long been known to be one of the best absorbers of slow neutrons available. Cadmium is known to consist of eight different kinds of atoms ranging in mass from 106 to 116 times the mass of hydrogen. Recently[4]

[4] "Absorption of Slow Neutrons by Cd-113," by B. J. Moyer, B. Peters, and F. H. Schmidt, *Physical Review*, vol. 69, June, 1946, p. 666.

it was shown that the abnormally high neutron-absorption cross section could be attributed entirely to one type of cadmium atom, the isotope of mass 113, which has an abundance of only 12 per cent. In spite of the fact that cadmium is a very good neutron absorber, 8 times the absorbing power would be available if this particular isotope could be isolated in quantity.

This fact is mentioned, not because cadmium is of more or even as much interest in atomic-energy work as are other elements, but because it shows so strikingly how some atoms of an element have quite different nuclear properties than others. The nuclear properties which are ordinarily observed for an element are in reality the weighted average properties of the several isotopes which make up the element. Perhaps the day is not far distant when separated isotopes of any element will be available at reasonable cost. If this ever happens, it will mean having additional building materials for atomic reactors at our disposal, because then elements may be utilized which now are not acceptable owing to the objectionable properties of one or more of their isotopes. At the present time the separation of isotopes is so difficult and expensive that only in the case of uranium does it pay to carry out the separation.

Figures have been given showing that if 1 lb of uranium, an amount about the size of a golf ball, undergoes fission, there will be released energy in amount roughly equivalent to 200,000 gal of gasoline. To the average motorist this would be enough energy to run his car for 200 years. Unfortunately, there is a hitch in all this. It has been estimated that in order for it to be safe for a human being to be near an atomic reactor, at least 50 tons of shielding material is required—an amount somewhat more than a motorcar can stand! While this rules out small mobile installations, such a weight of shielding would not be particularly detrimental in stationary units or large propulsion units such as might be used on ships.

USE OF HEAVY SHIELDS

Why must such heavy shields be employed? In answering this question, it must be known what is being shielded against. First, there are the neutrons, the particles which make the chain reaction possible. It has already been indicated that for efficient operation of the reactor as many as possible of the neutrons should be utilized in producing more fissions. This suggests that the pile be surrounded by an envelope of an element which has the property of reflecting neutrons readily without absorbing them. While such an envelope will help reflect a fair proportion of the neutrons which would ordinarily escape back into the pile, it still would permit a large number to leave. Thus to protect personnel, additional neutron-absorbing material is required.

Many of the fission fragments formed are highly unstable and decay to form more stable atoms. In the process, gamma rays are emitted. These, like x rays, are electromagnetic in character but because of the higher energy are more penetrating. Like x rays, they are absorbed most readily by the heavy elements. In practice, concrete has been used as an absorber for both the neutrons and the gamma rays.

CONCLUSION

In this brief discussion only a few of the problems associated with the atomic processes have been touched upon. There has not been opportunity to discuss the very interesting engineering problem of the regulation of the power output of the reactor by means of automatic adjustment of the position of neutron-absorbing control rods in the reactor. This is a broad subject in itself.

The author has touched on a number of new concepts or terms which form part of the vocabulary of atom workers. Fission cross sections, absorption cross sections, scattering cross sections, moderators, and reflectors have been presented. However, such things as radiation stability, homogeneous or heterogeneous reactors, power ratings of reactors, any of the special instrumentation required, or the health problems encountered in connection with atomic reactors have not even been mentioned. As in any new field, new terms do not always mean the same thing to all people. Before any large-scale use can be made of atomic energy, engineers and scientists must work together and agree on nuclear codes and standards to insure an orderly and safe development of the field. By setting up a committee to consider these matters this Society can make a real contribution toward advancing the future of atomic-energy power generation.

The problem of producing atomic energy is largely one of making efficient use of neutrons. This and the concept of atomic fission are really the only basically new factors with which the engineer must contend. Otherwise, the problem of producing atomic energy involves merely modifications of problems which engineers have already solved or will solve in connection with other work. Thus, there are many developments which will go hand in hand with those already being carried on in industry, and engineers can contribute substantially toward making atomic energy an everyday reality merely by extending their scope of operations.

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A THERMOMETER capable of accurately, automatically, and continuously measuring the temperature of the free air around an airplane in flight was developed by the Rockefeller Institute for Medical Research, New York, N. Y., during the war, according to a U. S. Navy report (PB-60419) now on sale by the Office of Technical Services, Department of Commerce, Washington 25, D. C.

It is stated that the design of the thermometer avoids errors arising from compression, friction, and radiation in air speeds as high as 500 mph.

The thermometer consists essentially of two oppositely oriented copper-constantan thermocouple elements, a sturdy well-insulated thermostat, and a pointer-indicating galvanometer. The complete assembly weighs little more than 4 lb, the report states.

Each thermocouple element is housed in a polished chromium conical unit—1.6 in. in length and 0.76 in. in base diameter—at the end of a 2.5-in. streamlined strut. The struts are 3 in. apart and are fastened rigidly and perpendicularly to one side of a rectangular aluminum-alloy plate.

The thermostat is bolted to the other side of the plate and is hidden from view when the plate is placed into position on the underside of an airplane wing. The thermostat contains a "thermoswitch" and an electric heater for producing a constant temperature of 65 C as a basis for galvanometric comparison with the temperature of the free air.

Facing the two thermocouple elements in opposite directions automatically cancels errors attributable to the compression of air and air friction during flight. The conical design of the thermocouple housings, the chromium finish of both the housings and the struts, and the mounting of the complete instrument beneath a wing surface are said to help minimize radiation losses.

The ENGINEERING PROFESSION *in* TRANSITION

Report on E.J.C. Economic Status Survey

By WILLIAM N. CAREY

CHAIRMAN, E.J.C. COMMITTEE ON SURVEY OF THE ENGINEERING PROFESSION

"THE Engineering Profession in Transition," as its author, Andrew Fraser, the consultant engaged by the Engineers Joint Council Committee on Survey of the Engineering Profession, has titled the 1946 survey on economic status of the profession conducted by the committee, is being printed. When this revealing and important self-analysis of the engineering profession is published, it will be available for general sale at $1.

In this article, Colonel Carey, chairman of the E.J.C. committee that conducted the survey, sets forth salient points uncovered in the project, which dates back to 1945 when committee work was first begun. Of particular interest in this study, restricted for the first time to persons identified through their membership in the six national professional engineering societies as being qualified members of the profession, are the comparisons afforded for the before-, during-, and after-the-war years of 1939, 1943, and 1946. The participating societies are: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, and American Institute of Chemical Engineers, which make up the Engineers Joint Council, and National Society of Professional Engineers, joining in this project by invitation of the Engineers Joint Council.

IT BECOMES increasingly apparent that the 1946 survey of the engineering profession, now being published in an 80-page 9 × 12-in. E.J.C. Bulletin under the title, "The Engineering Profession in Transition," will be a most valuable and interesting document to those in the profession. Dealing with the general and specific factors that affect engineers' employment opportunities and designed to establish relationship of earning capacity to these individual factors, the report covers the topics of geographical location, general field of employment, and industry field, and includes a wide range of occupational statuses. Completion of the report marks a milestone of accomplishment in the co-operative professional activities of Engineers Joint Council. It furnishes the profession with up-to-the-minute economic-status data based on answers to questionnaires sent to 87,000 professional engineers, all members of the six national engineering societies participating in the project.

Compilation of the report represents an expenditure by the engineering-society group of $16,000 and more than that amount in addition in value derived through the co-operation of the Bureau of Labor Statistics, U. S. Department of Labor, which furnished staff and equipment for tabulating returns from the precoded questions. All members of the survey committee were called upon to give freely of their time to the project. In round numbers, the completed manuscript represents expenditures approximating a $50,000 total. These expenditures brought the report to the finished-manuscript stage. Printing will be an additional expenditure to be met by the societies or by individuals desiring printed copies of the report.

In the space allotted here it is only possible to present some of the more immediately interesting conclusions reached on the basis of replies received to the questionnaires, on which there was a 53 per cent return. The report must be read in its entirety for an appreciation of the completeness and clarity of the wealth of statistical information covering the engineering profession there presented.

A marked change occurred in the ratio between the earnings of the older and the younger members of the engineering profession over the period 1939 to 1946. In 1939, private graduate employees with 35 to 39 year's experience earned a median salary of $550 a month, which is nearly 4½ times greater than the median $127 a month for newcomers to the profession in that year. In 1946 the corresponding difference in median salaries in this same grouping was $629 to $232, a ratio of 2¾ to 1 as against 4½ to 1 in 1939.

The report also establishes clearly that graduate engineers earn more than nongraduate engineers at all experience levels except for the first six years. Consistent with this is the fact that those with master's degrees earn more than those with bachelor's degrees, and graduates with the degree of doctor enjoy still higher earnings.

Another significant development is that the monthly salary rates structure of the engineering profession in 1946, with overtime payments no longer a factor, was not only much higher than that of 1939, but also exceeded the base-plus-overtime range of 1943. Further, this improved earnings status in 1946 was common to engineers in all general fields of employment, whether graduates or nongraduates and in both private and public engineering.

Younger engineers reported the greatest relative increases. For newcomers to the profession in 1946 the improvement was of the order of 88 per cent reflecting median monthly salary rates of $231 a month for 1946 as against $128 a month in 1939. Men with 6, and 12 to 14 years' experience received median rates in 1946 of $343, and $385 a month or, respectively, 60 and 33 per cent more than similarly experienced engineers had received in 1939.

Interesting data are revealed in the report regarding the differ-

TABLE 1 PERCENTAGE DISTRIBUTION OF THE ENGINEERING PROFESSION IN 1946 ACCORDING TO GENERAL FIELD OF EMPLOYMENT

	Per cent
Civil engineers	23.6
Mining and metallurgical engineers	7.6
Mechanical and industrial engineers	23.7
Electrical engineers	25.2
Chemical engineers	9.8
Other engineers	6.5
Nonengineers	3.6

GEOGRAPHICAL DISTRIBUTION OF THE ENGINEERING PROFESSION IN 1946

ential which begins to assert itself between graduate engineers and nongraduates after the first 6 years of experience. During this period, as has been stated, the differential is negligible. At the 9 to 11 years' experience level in 1946, engineers with bachelor's degrees reported median earnings of $389 a month, whereas engineers with incomplete college courses or no college education reported, respectively, $363 and $374 a month. By contrast, while masters earned $409 a month, doctors earned as much as $466 a month. Significantly, at higher experience levels, the earnings' advantage in favor of graduates becomes more and more pronounced.

The report shows that the profession in 1946 was not a "closed shop" for graduates only. This is evidenced by the fact that 17 per cent of all engineers reporting included men who had incomplete college training or none at all. Bachelor's degrees were held by 64 per cent, while 15 per cent reported graduation at the master's level and 4 per cent were doctors.

Really significant differences in engineers' earnings begin to appear only beyond the 8 years' experience span (i.e., 31 years of age). The extent of these differences, as might be expected, depends largely on the general field of employment of the individual, educational qualifications, and occupational assignment. For example, in 1946, median base monthly salary rates ranged from $224 to $256 a month among 10 groups of newcomers to the profession, 6 groups engaged as employees in private and 4 in public engineering. By contrast, among the six private engineering groups the range in median rates earned by engineers in the 35 to 39 years' experience span was from $513 a month for civil engineers to $825 a month for chemical engineers. Second in ranking order came mining-metallurgical engineers with $693 a month, followed by $650 a month for men in "other engineering fields," electrical engineers with $604 a month, and $587 a month in the case of mechanical-industrial engineers. This steady progression in earning capacity with advancing years of experience also is characterized by a persistent and substantial spread in earnings at every experience level. This spread becomes particularly accentuated in the upper 10 and 25 per cent earnings groups.

The composition of the profession in 1946 by general field of employment showed nearly 73 per cent about equally divided among civil, electrical, and mechanical-industrial engineers. There were 10 per cent chemical engineers, 7 per cent mining-metallurgical, 6 per cent in other engineering fields, and the remaining 4 per cent were engaged in nonengineering work. Except for civil engineers, whose work was divided approximately equally between public and private engineering, those in the other 6 fields were overwhelmingly dependent upon private engineering for their employment. Nearly 60 per cent of the country's professional engineers in 1946 were in the manufacturing and construction industries.

Among the 29 occupational statuses reported for 1946, nearly 30 per cent of all engineers were engaged in technical administration-management. Design, development, and applied research attracted 15, 7, and 5 per cent, respectively; supervisory construction, college or university teaching, private firm consulting, and sales each included from 4 to 5 per cent. Among the remaining 21 statuses, the percentages ranged from less than 1 to 4 per cent.

When related to each of the 29 occupational statuses, the median monthly salary rates among the newcomers to the profession in 1946 ranged only from $206 to $248. At the 6 years' experience mark, the range had increased from $280 to $378 a month. But at the 12 to 14 years' experience level, while engineers engaged in routine work such as drafting earned $310 a month in 1946, men engaged in nontechnical administration-management earned as much as $555 a month.

The relationships found to exist between earned annual incomes reported for 1939 and 1943 only, and monthly salary rates in these same years, make it clear that the opportunity to earn

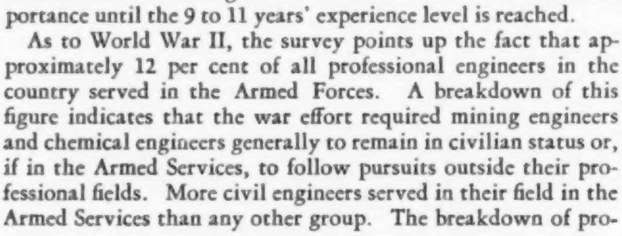
substantially more than base salaries is confined to a very small and experienced segment of the profession.

An earnings differential pattern that persisted to the end of the active experience cycle of professional engineers is disclosed by the 1946 information. This begins at the 15 to 19 years' experience mark and indicates that, at the median earnings point, civil engineers generally receive the lowest remuneration, not only in private engineering, but also in nonfederal-government employment in public engineering. Furthermore, the earnings of engineers in private engineering employment exceed by far those reported for public engineering, with private chemical-engineer employees consistently reporting the highest remuneration at all experience levels.

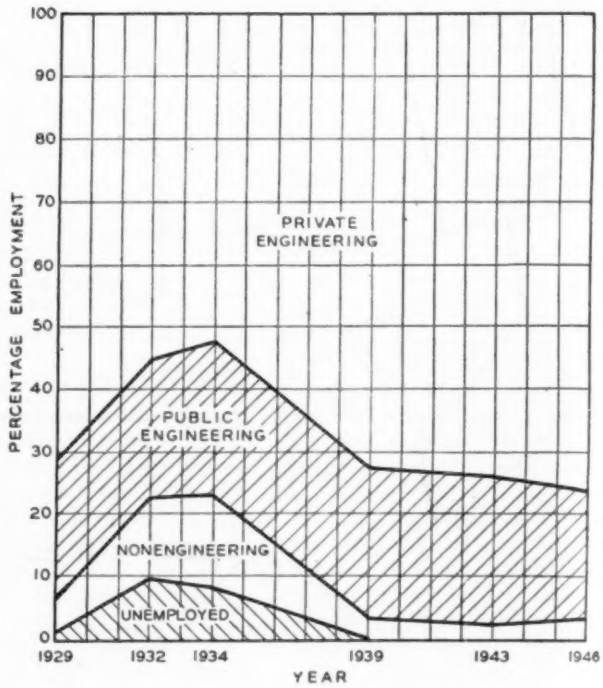
While the median monthly salary rate for newcomers in the civil engineering field is the highest of all, it is the lowest at the 40-year experience level. The median rates of civil engineers steadily increased from $243 for newcomers to $513 for men with 35 to 39 years of experience while engineers in "other engineering fields" increased from $224 to $650 a month. The corresponding range for chemical engineers was from $256 to as high as $825. Between the two extremes came mining-metallurgical engineers with median earnings that increased at the same experience levels from $236 to $693 a month, and below the "other engineering" group, but above the civil engineers, were the electrical engineers, whose reported median earnings increased from $237 for newcomers to $604 at the 35–39 years' experience levels, and the mechanical-industrial engineers who had a corresponding experience span increase from $225 to $587 a month.

Perusal of employee engineers' earnings indicates that they must be modified when related to educational qualifications. For example, the median earnings of the graduate group in 1946 increased from $232 a month to $346 a month over the experience spans 1 to 6 years, whereas the median earnings of the comparable group of nongraduate engineers increased from $295 to $317 a month. At the 7 to 8 years' experience mark, nongraduate private employees earned $344 a month, but graduate private employees earned a median rate of as much as $365 a month. On the other hand, in public engineering, the earnings differential in favor of graduates does not assume statistical importance until the 9 to 11 years' experience level is reached.

As to World War II, the survey points up the fact that approximately 12 per cent of all professional engineers in the country served in the Armed Forces. A breakdown of this figure indicates that the war effort required mining engineers and chemical engineers generally to remain in civilian status or, if in the Armed Services, to follow pursuits outside their professional fields. More civil engineers served in their field in the Armed Services than any other group. The breakdown of pro-



MEDIAN BASE AND BASE-PLUS-OVERTIME MONTHLY SALARY RATES OF GRADUATE AND NONGRADUATE ENGINEERS IN PRIVATE AND PUBLIC EMPLOYMENT



THE CLASS OF WORKER STATUS OF THE ENGINEERING PROFESSION, 1929–1946

fessional engineers in the Services in World War II is: Civil, 29 per cent; mechanical-industrial, 15 per cent; electrical, 14.7 per cent; chemical, 1.8 per cent; mining, 1.0 per cent; other engineering, 14.2 per cent; and nonengineering, 24.3 per cent.

Comparisons also confirm what might be assumed, that the demands of the Services were for younger men. Apparently the Services utilized professional engineering skills to a high degree. The effects of demobilization were such that the patterns of disposition with respect to the class of worker and industry field were virtually the same in 1946 as had existed 7 years earlier in 1939. The changing pattern with respect to occupational status reflects the advance which occurred in engineers' over-all economic status despite service either in the Armed Forces or as civilians. As to comparative earnings between engineers in the Armed Forces in 1943 and those who were civilians, the survey indicates that base median monthly rates were approximately the same at each respective experience level for the two groups.

A wealth of additional information is contained in the report which goes into employment opportunities by geographical location, general fields of employment. In this brief résumé, it has been attempted merely to present some indication of the magnitude and scope of the survey. As stated earlier, a reading of the full report is required for full appreciation of the completeness and clarity of the statistical information covering the engineering profession.

The report will do much toward increasing the tempo of studies and discussions on the need for reorientation of engineering education and practice which have been under way in many quarters. In short, the 1946 survey of the engineering profession, so aptly titled, "The Engineering Profession in Transition" is, to state it rather unprofessionally, the "where we have been" on the economic status of the engineering profession, which can serve as an important, factual guide to "where do we go from here?"

Manufacturing LAMINATED TENNIS RACKETS

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FEW manufactured items produced in large volume present as many or as diversified problems in design, tooling, and fabrication as those encountered in the manufacture of sporting-goods equipment.

Sporting goods as a whole, whether for group or individual use, are produced with the foregone acceptance that they will be subjected to constant and extreme abuse while in play, either from impact, torsional strains, abrasion, etc., or in some cases a combination of all these at the same time. Despite this abuse, they must retain their original uniform qualities of size, shape, and life for long periods.

In addition, the problems of weight versus strength, and weight versus size are as vital in sporting-goods-equipment manufacture as in the aircraft industry, while uniformity of specifications, i.e., dimensional limitations, resiliency, rigidity, rebound, and aerodynamic flight, must be maintained within the closest of tolerances at all times.

Probably one of the best examples to illustrate the problems of sporting-goods manufacture is the fabrication of laminated rackets for tennis, badminton, and squash, totaling over one million pieces annually.

FIG. 1 HISTORICAL GROUP OF TENNIS RACKETS DATING ABOUT 1870–1880

HISTORICAL

Rackets for games of sport have been manufactured for over 150 years, presumably at first by the user himself, to his own design and to suit the particular prupose or game for which it was intended. As time standardized both the rules of the game and the implement, local carpenter or cabinet shops began producing the rackets in limited quantity for their own communities. Late in the nineteenth century, the demand had increased sufficiently to justify the setting up of industries specifically to manufacture sporting-goods equipment.

Early rackets were made from any of the well-known long fiber hardwoods such as ash, hickory, and oak, and were steam-bent from one piece of stock to the desired shape of the finished racket. Early shapes generally were of the flat-headed type with right-angular bends tapering to a V-shaped throat wedge. Variations of this type later came to the flat-headed lopsided rackets with an irregular shape either to the right or left depending upon the preference of the player. Early stringing ran from leather strings to rawhide, and eventually to sinews and gut. Typical rackets of the 1870–1880 period are shown in Fig. 1.

Controlled manufacture and research through the years gradually evolved standards for racket raw materials, shapes, weights, balance, etc., which were adopted by the industry and tennis association generally.

One specific example of research and standardization which was in a large measure responsible for the laminated manufacture of rackets was the discovery that the best racket material was second-growth mountain-grown ash. It was further found that this ash should be cut from logs having 6 to 12 annual rings per inch width to produce the strongest and most resilient frames. Lumber-yield figures, however, soon showed that only $33^1/_3$ to 40 per cent of the logs cut showed the 6 to 12 rings to the inch structure, and over 60 per cent of the lumber with the correct grain count was mixed or red in color, producing a very low net yield of white ash having the 6- to 12-ring count.

Research further proved that steam-bending of the white-ash sticks set up stresses and strains due to the irregular and reversed bent shape of the racket which tended to permit or promote warping and twisting of the racket when heavy stringing loads were applied.

A constant and long period study of this condition finally indicated that the inability of the wood fibers to slide over each other sufficiently at the moment of steam-bending to permit either shortening or elongation of each particular grain, set up the strains which were causing the warpage at stringing.

A graphic example of the strain set up and left in by steam-bending is illustrated in a modern 10-ply cold-bent tennis frame, i.e., before bending all 10 strips or laminations are exactly the same length (64 in.). Upon bending around bending jigs and forming the shape of the racket frame the tenth or outside lamination is $1^3/_4$ in. shorter than the no. 1 or inside lami-

Presented at the Wood Industries Division Conference, Madison, Wis., June 12–13, 1947, of The American Society of Mechanical Engineers.

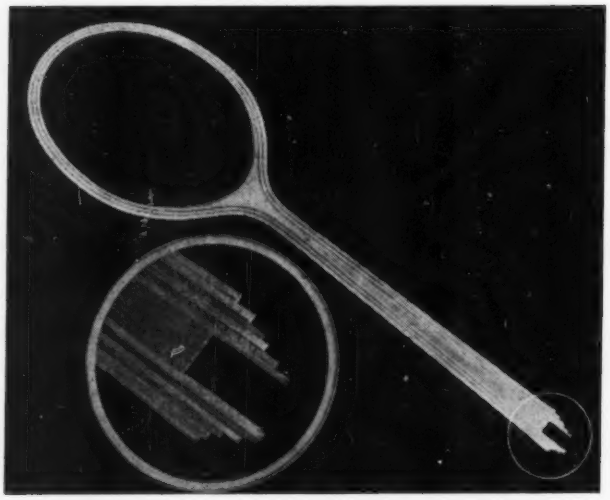

FIG. 2 ILLUSTRATING THE PROGRESSIVE SHORTENING OF LAMINATIONS FROM INSIDE TO OUTSIDE OF BOW AS FRAME IS BENT INTO SHAPE

(All laminations are exactly the same length, i.e., 64 in., before being bent into a frame.)

nation, with the intermediate laminations showing a progressive shortening from the inner to the outer lamination, Fig. 2.

Obviously, this lamination shortening or elongation cannot take place in a one-piece steam-bent frame, and the inevitable result is the internal strains referred to in the foregoing.

With this knowledge, it was evident that from the standpoint of economical lumber yield and the production of the strongest, most resilient racket, a laminated-frame construction was essential.

THE MODERN LAMINATED RACKET

The laminated construction of rackets permits the use of veneers produced by any of the conventional methods, i.e., rotary cut, sliced, or sawn, and allows multiple laminations, if preferred, of several frames at one bending by utilizing the wide sheets of material produced in the veneer-manufacturing processes. Veneers best suited for racket manufacture are ash, hickory, maple, birch, beech, and oak, with decorative or trim laminations in mahogany, walnut, gum, cane, bamboo, etc.

The production of laminated rackets necessitated a thorough restudy of laminating materials to determine correct thicknesses and combinations of various species to produce a frame with the playing characteristics of the ideal material, i.e., 6 to 12 annual rings per inch width second-growth white ash.

It was found, for example, that the use of many plies of thin laminations of 0.032 in. to 0.040 in. simplified manufacturing considerably with lower pressures required for bending, etc., but the many glue lines produced an overweight frame, while the thin lamination soon fatigued under heavy play and produced a "ropey" racket without life or the power to produce the impact load required in a hard drive. Later experiments, again with thin laminations and less flexible glues (ureas), also produced overweight frames but instead of showing "ropey" tendencies of the more flexible animal glue, they showed low impact strength and snapped off with abrupt breaks at the frame shoulders when a hard drive shot was made.

This "ropiness" or failure to maintain shape and life in play and low impact was characteristic of all frames laminated with rotary-cut veneers of all species even when varying combinations of thicknesses were used. It has been found, however, that the thinner the lamination used, the more pronounced are these troubles, while a reduction of "ropiness" and increase in impact resistance results when heavier plies are used up to $^3/_{32}$ to $^1/_8$ in. The rotary-cut material, in other words, produces the least desirable laminated frame from the standpoint of play, but probably the most desirable type from the standpoint of economical manufacture.

Sliced veneers in the correct thickness combinations produce playing qualities more closely approaching the qualities of white ash, and like rotary-cut veneers, permits material cost economies in manufacture. Both of these knife-cut veneers, however, are weaker than sawn material and do not have the resilience and impact resistance of sawn veneers. Contributing factors to their weakness probably are the prolonged hot soaking before rotary-cutting or slicing, the grain fracturing or opening particularly in rotary-cutting, plus the forced fast drying after cutting, possibly setting up unequal stresses and strains in the individual laminations.

Sawn laminated veneers for racket manufacture are veneers only in so far as their dimensions are comparable with the thicknesses of the rotary cut and sliced stock. Actually, sawn laminations are boards approximately 64 in. long, 1 in. in thickness, and from $^1/_{32}$ to $^1/_8$ in. in width.

Sawn laminations, as used by the author's company, are entirely of second-growth ash, ripped from boards 1 in. in thickness on special saws which permit the following of the grain of the board, thereby producing laminated strips having full continuity of fiber and resulting full strength.

Cost of producing laminated strips in this manner is four to five times greater than that of rotary-cut veneers and two to three times greater than the cost of sliced veneers. Waste is of course a highly contributory cost factor in strip-sawing, where, for example, a saw $^3/_{32}$ in. in width will cut away in sawdust the equal of three full strips when $^1/_{32}$-in. laminations are being produced.

After cutting, these sawn strips are stacked in piles properly separated with sticker strips and either air- or kiln-dried to 8 to 12 per cent moisture before they are ready for racket manufacture.

PROCESSING OPERATIONS

Another important reason for manufacturing rackets by the laminated method, over the steam-bent single-stick process,

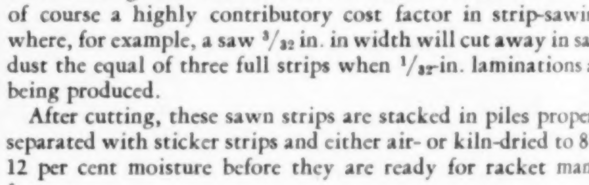

FIG. 3 COMPONENT PARTS OF A MODERN LAMINATED TENNIS FRAME ASSEMBLED AT ONE TIME IN THE FRAME-BENDING OPERATION

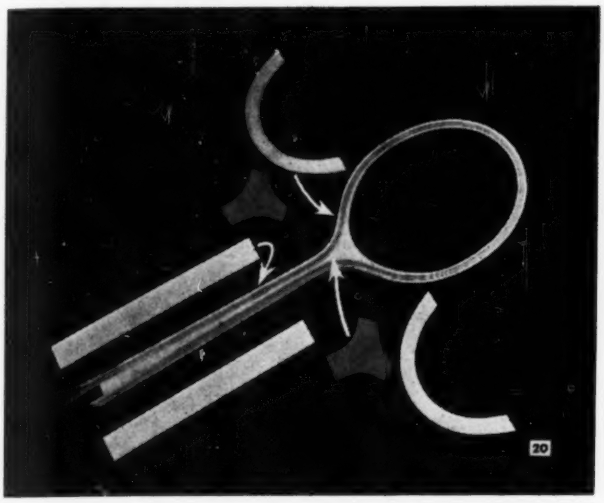

FIG. 4 COMPLETELY ASSEMBLED FRAME AFTER BENDING OPERATION SHOWING HANDLE FLAKES, FIBER FACES, AND KRO-BAT OVERLAYS, WHICH ARE APPLIED IN SUBSEQUENT SEPARATE OPERATIONS

lies in the completed assembly made possible in the laminated system wherein 8 to 12 laminations, plus the throat wedge, handle plug and inside shoulder reinforcement are glued up in a single operation, permitting the perfect compatibility of all the curves and angles of difficult gluing shapes. Component parts of a modern racket frame are shown in Fig. 3.

In the steam-bent process, the frame must be dried for 3 days to a week after steam-bending while all the other parts must be glued in subsequent single operations, setting up unequal strains and stresses whenever two curved or angular surfaces do not coincide exactly in shape.

Bending Laminated Frames. In laminated-frame bending all the laminated strips are put through a conventional double-roll spreader at one time and assembled into a complete frame with all other component parts mentioned, by means of hydraulic-pressure jigs.

The entire assembly process requires but 45 seconds. After bending in the bending jig, clamps are applied, and the complete bending jig is placed in a kiln at controlled heat and moisture suitable to the particular type of adhesive used.

Upon removing from the kilns, the frames are stripped from the jigs and clamps and allowed to set for 24 hours to reach equilibrium in warping or setting of shape, before they are buzz-planed on one side and surface-planed to correct thickness on the other. Fig. 4 shows a completely assembled frame after the bending operation, with additional parts which are applied in subsequent operations.

Marking and Drilling. After planing, frames are placed on head forms which automatically mark the stringing-hole location on the inside of the bow. Contrary to the popular belief, the 60 to 70 holes for stringing in a racket bow are hand-drilled singly and not in multiples or groups by a complex drill jig; accuracy, speed, and tool life still indicate the hand method as best despite considerable engineering study and experimenting with automatic drilling devices.

Holes are drilled from the inside of the bow at the center line of the thickness of the frame and taper toward the outside of the frame at approximately a $22^1/_2$-deg angle, each succeeding hole being staggered in the opposite direction from the one next to it, resulting in holes on the outside of the frame being placed at 45-deg angles from each other. This is done to prevent heavy stringing tensions from pulling the cord through the laminations with the grain, as drilling in this manner, in effect, makes the cord run across the grain when it is carried from hole to hole in stringing. Fiber laminations placed between the ash lamination when the frame is bent also tend to prevent splitting of the frames as stringing loads are applied.

Grooving and Shaping. Holes around the outside top of the bow are connected by grooves to embed strings in the frame so that they will not be worn by contact with the court in play. These grooves are cut by a small high-speed router from hole to hole entirely by eye and hand by a skilled operator, as jigging for automatic cutting requires more time to set the frame in the jig than is required by an operator to make the approximate 20 grooves required.

Drilling and grooving are followed by conventional shaper operations consisting of chamfering the inside or outside of the bow to a particular radius or shape, and sizing of the handle to width, etc.

Fiber Facing. Next are applied the fiber faces which extend from the shoulder of the frame across the entire throat and down the handle. This tough, easy gluing material ties the shoulder, throat, and handle laminations together and prevents splitting of individual parts, although not interfering with flexibility or torsion required in play.

The action of a tennis frame when in play consists of a bending or arcing back from the point of contact with the ball as much as $2^1/_2$ in. in back of the handle line when a service blow by an expert is hit. This bending back of the bow tends to twist the frame laminations at the racket throat away from the throat glue joints to compensate for the torsional strains in the upper bow, and this continuous twisting and flexing would soon fatigue and soften the frame shoulder so that the racket would not be capable of delivering a hard driving blow.

Shoulder Overlay. To overcome this difficulty, the shoulder overlays or kro-bats are applied. These consist of two solid steam-bent, or cold-laminated, maple, beech or birch half-moons approximately $^1/_8$ in. thick $\times$ 1 in. wide and bent to coincide exactly with the frame shape across the throat and shoulders. One of these overlays is glued to each face of the frame extending up the shoulders and across the throat where it is shaped, curved, and tapered to flow into the frame lines.

With the addition of the half-moon overlays or kro-bats across the shoulders, the action of the bow upon hitting a heavy service or driving blow becomes a smooth balanced arc from the tip of the frame to the handle, eliminating the sharp hinge

FIG. 5 THE KRO-BAT—A MODERN LAMINATED RACKET FRAME

action of the throat and shoulder sections which so rapidly fatigues the frame.

Final Wood-Room Operations. Balance of wood-room operations are conventional, such as application of handle flakes, shaping, etc., until the frame reaches the handlemaker where the entire frame is given a cabinet finish and all lines and curves are made to flow and blend together as various toolmarks from previous operations are removed.

Handle flakes are of many types and shapes from the short type ending just above the leather grip to the Australian type extending to the kro-bat overlays at the throat, these two extremes producing on the one hand a very flexible whippy handle, while on the other a stiff unbending type forcing all the bend and whip into the head of the frame.

Weighing and Balancing. After completing the course through the wood room, frames receive a final "in the white" inspection which is the sixth they have been through since bending. At this point also they are weighed and balanced to a predetermined requirement. To weigh and balance a frame, a $^3/_4$-in. hole is drilled for 6 in. up into the handle into which is placed a special high-gravity flexible plug, which, by its addition weights the frame, and by its positioning in the handle locates the balance point.

Every quality-model racket made must be finished in three basic weights, i.e., light, medium, and heavy. Strung rackets run 13 to $13^1/_2$ oz light, $13^1/_2$ to 14 oz medium, and 14 to $14^1/_2$ oz heavy. In addition, each weight grouping must be furnished in three handle sizes and three balance points, i.e., even balance, head heavy, and handle heavy. In other words, to furnish one model in all the weights, handle sizes, and balance combinations possible would require 27 pieces.

Finishing. After balancing and weighting the frames, they continue to the finishing departr ent where they receive one coat of silica-type filler, one to two coats of pigmented lacquer as required in the color or trimming scheme, and three full spray coats of clear lacquer.

Between coats, decorative and identifying decalcomanias are applied as well as plastic-type bindings which are applied in softened form from exposure to solvents and shrink tightly on the shoulder and handle of the frame where specified. On top-model frames, bindings of individual braided nylon strings are applied rather than the plastic type.

When the lacquered frame has become thoroughly dried and seasoned it is buffed on a polishing jack, using cloth wheels, to a high-gloss polish. Lacquer finishes are of a special type developed for tennis frames and must have high flexibility, toughness, abrasion resistance, great adhesion, plus a water-clear color and good polishing characteristics.

Next, butt leather is applied on the end of the handles, beveled leather to flare the end of the grips, and leather grips of varying quality to match the type and quality of the particular frame model. A modern laminated racket is shown in Fig. 5, before the stringing operations.

STRINGING OPERATIONS

From the finishing room, frames go to the stringing department where they are strung with silk, nylon, or animal gut, depending upon the specifications of the particular model. Racket-stringing is a hand operation consisting, in the conventional racket, of 18 main or vertical strings and 20 to 22 cross-strings. This is an operation where operator skill is most important, as an inferior stringing job can spoil the finest racket. Skilled operators can string an entire racket in 15 to 30 min, depending upon the type of string used.

Considerable variations in opinion exist in the correct tension to which a tennis frame should be strung, and the research laboratories of the author's company have made a long study to determine the correct standards for the various types of string, i.e., silk, nylon, and animal gut.

Animal gut is by far the liveliest and most active string ever developed for tennis play and is made from high-quality lamb casing with considerable care and manufacturing control, equaled only by the manufacture of surgical sutures. This care in manufacture, plus the limited quantity available, make the consumer price so high that animal gut generally is used by top-ranking players only. Animal gut is highly susceptible to moisture and humidity changes and, when strung tightly, will snap easily when exposed to humid conditions, this breakage being due to an increase in diameter of the strings with resultant increased loadings beyond their maximum tensile strength.

Animal gut reaches its greatest resiliency at an 80-lb tensile loading and falls off rapidly in liveliness and becomes boardy when tension is increased above this point. It is very difficult to determine an 80-lb loading in tennis-stringing, but a study in pitch or musical tone, plus the microscopic markings applied on the gut before loading indicate that a 50-lb stringing job of main and cross-strings will produce an over-all 80-lb loading on the frame or the best playing tension.

Nylon stringing possesses good resiliency, about 80 per cent of animal gut, and has excellent abrasion resistance. It is unaffected by humidity or temperature changes and is the ideal stringing for 80 per cent of the players.

Silk stringing is rapidly being replaced by nylon. It is the least lively of the three strings and is somewhat affected by humidity and temperature changes. Its resistance to abrasion is fair and it increases in liveliness up to 100 lb stringing tension.

FINAL TESTING

Stringing is the last actual manufacturing operation and is followed only by final over-all inspection and laboratory routine tests, and quality-control checks on a certain quantity of each day's run. These laboratory tests have been repeated and checked over such a long period that they can be correlated to actual playing expectancy and give the assurance that certain results clearly indicate what can be expected from actual use.

An example of these tests is the whacking of frames made with many plies of 0.032-in rotary-cut laminations and using a nonflexible urea glue. On being placed in the whacking test they were broken in 5 minutes while frames made of sawed ash and using the same urea glue were whacked for 4 hours and were uninjured when removed. This whacking test consists of two tennis frames rotated in an 8-ft circle at speeds to assure velocity nearly double the hardest service blow; and $^1/_2$ hour successful test will, in effect, guarantee a moderate-priced racket a season's satisfactory performance.

Another interesting test consists of dropping a tennis frame just after the first planing operation, and prior to drilling, on a steel block from a height of 5 ft. Impact of this blow will immediately detect weak joints or brashness in the wood. Standard sawed-stock ash frames have been dropped 40 ft to a cement floor without damage, and then strung up and run 4 hr in the whacking test without injury.

CONCLUSION

In closing, it should be pointed out again that the impact blows and torsional strains which must be sustained by tennis, badminton, and squash frames, are tremendously high when the light weights of the frames are considered, i.e., a tennis frame will weigh from $12^1/_4$ to $13^1/_4$ oz, a badminton frame not over $4^1/_2$ oz, and a squash frame from 8 to 9 oz.

It is therefore highly important that the finest quality materials and closest and best manufacturing controls and procedures be maintained to assure a satisfactory product.

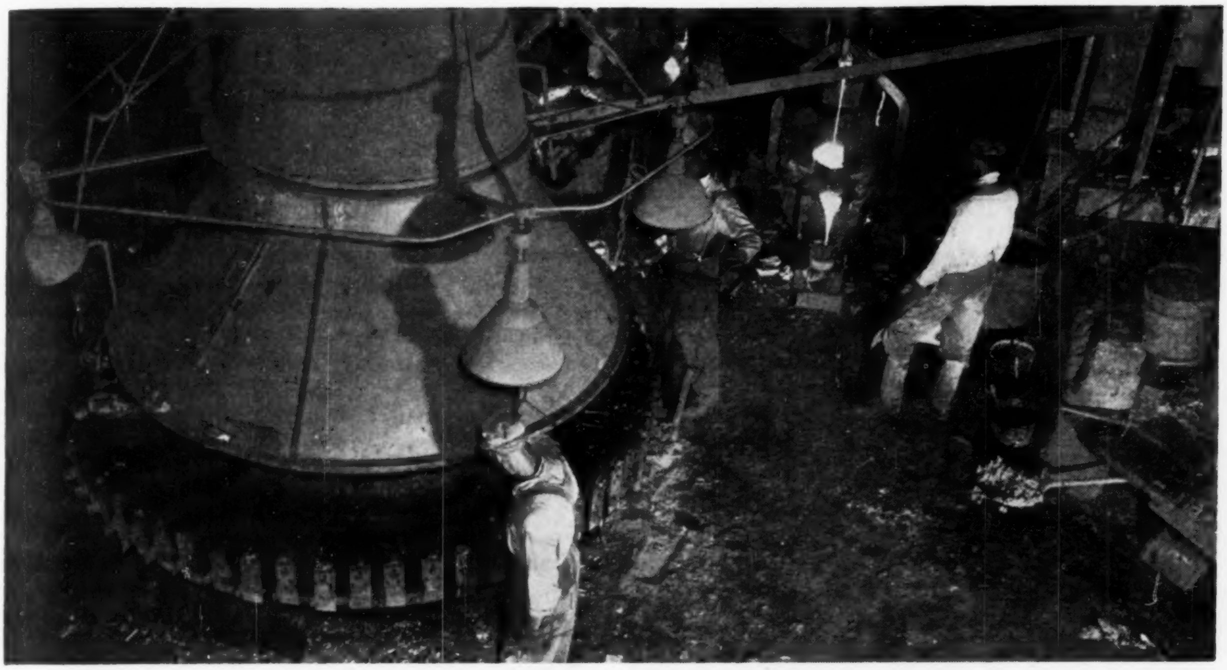

FIG. 1 GENERAL VIEW OF BOLT-CASTING UNIT
(Mixing ladle at right center; acetylene torch at extreme left.)

CAST BOLTS *for* PIPE JOINTS

By C. K. DONOHO

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BOLTS used for assembling mechanical joints for pipe constitute a vital part of the pipe-line construction. The bolts must maintain adequate compression of the gasket against all challenges of internal pressure, external load, joint movement, and corrosion. The primary qualifications for such a bolt are (1) high yield strength, (2) toughness and ductility sufficient to withstand any ordinarily encountered shock or bending stresses, and (3) corrosion resistance equal to, or better than, the pipe with which it is used.

For cast-iron pipe joints, several types of bolts have been used. Mild-steel bolts have the requisite ultimate strength and toughness but may be low in yield strength. With a strong arm on the bolt wrench, mild-steel bolts have been stressed beyond the yield point so that they continue to stretch after the joint is made, eventually permitting the joint to leak. In this case high ductility is actually detrimental, since it is better for the bolt to break when stressed past the yield point, in which case it may be replaced immediately. The corrosion resistance of steel bolts is an important consideration. Since the bolt is an exposed vital element, corrosive conditions often may cause failure of the bolt before the pipe itself has been affected appreciably. Galvanizing or cadmium plating of steel bolts affords only temporary protection in aqueous or underground corrosive environments.

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Regular malleable-iron bolts also are low in yield strength and are approximately as corrodible as steel. High-strength, pearlitic, malleable bolts, alloyed for corrosion resistance, have given satisfactory service. Bronze and stainless-steel bolts may be used for the most severe conditions, but are relatively expensive. This paper describes one method of production of cast bolts with the desired qualifications for pipe-line service.

The metallurgical development was carried out by the author's company,[1] and a resulting application, known as the Acipco standard alloy cast-iron bolt, has been in continuous production since 1937. The principal use is for mechanical joints in cast-iron pipe lines for conveying liquids and gases, Fig. 2. Sizes cast range from $^5/_8$ to $1^1/_2$ in. diam, and 3 to 7 in. length, Fig. 3. The metal composition, method of casting, and heat-treatment of these bolts constitute a unique and interesting metallurgical process.

The metal is melted in a cupola and cast into individual metal molds (or dies) to form the bolt blank. Quick-freezing by reason of the chilling action of the metal mold causes the iron to cast "all white," i.e., essentially with no free carbon. Subsequent heat-treatment converts the hard, brittle, white iron to a malleable structure which is strong and tough, yet easily machinable. The metal-mold process allows the use of an iron composition radically different from that of ordinary cupola malleable, and the compositional changes permit complete malleableization with an unusually short anneal.

[1] U. S. Patent No. 2,220,792.

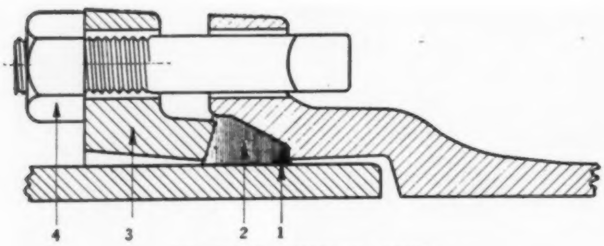


FIG. 2 TYPICAL MECHANICAL JOINT FOR CAST-IRON PIPE

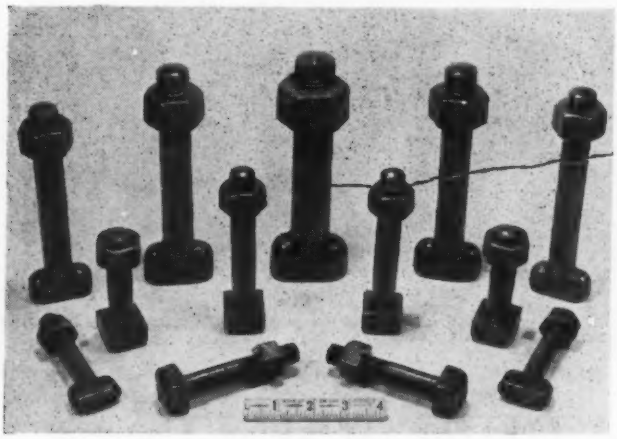


FIG. 3 A FEW STANDARD TYPES OF CAST BOLTS

MELTING PROCESS

At present melting is carried out in a 24-in-diam cupola, producing about 2 tons of molten iron per hr. The metal charge is composed essentially of steel, return scrap, and high-silicon pig iron. Iron-to-coke ratio is about 5 to 1. The molten metal flows continuously from the cupola breast into a mixing and desulphurizing ladle of capacity sufficient to hold 3 or 4 complete charges. From the mixer, iron is taken in 25-lb hand ladles for casting. The desired average analysis in per cent is as follows:

Total C	Si	Mn	P	S	Cu
2.50	3.00	0.85	0.12 max	0.15 max	1.25

Melting of iron as low as 2.50 per cent carbon in the cupola is facilitated by the high silicon and copper contents, which reduce the carbon solubility. The temperature of metal from the cupola is 2750 F to 2800 F, and casting temperature averages about 2450 F.

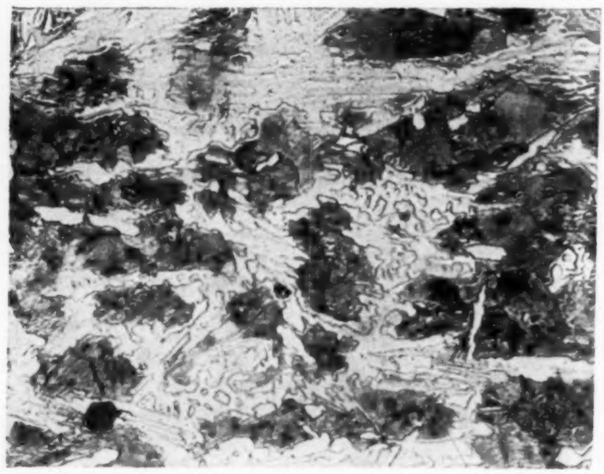
CASTING

Bolt blanks are cast one at a time in split metal molds mounted on a turntable carrying 60 molds. The turntable makes one complete revolution every 2 to 3 min. At the pouring side of the turntable, the two-part molds are held in the closed position by springs. At the opposite side pusher arms, acting on a cam at the center of the wheel, separate the split molds to allow removal of the solidified castings. The molds are open at the top and are poured by hand, head up, the head height being controlled by the pourer. Bolts are cast and stripped on one turntable at the rate of about 25 per min. A general view of the bolt-casting unit is shown in Fig. 1.

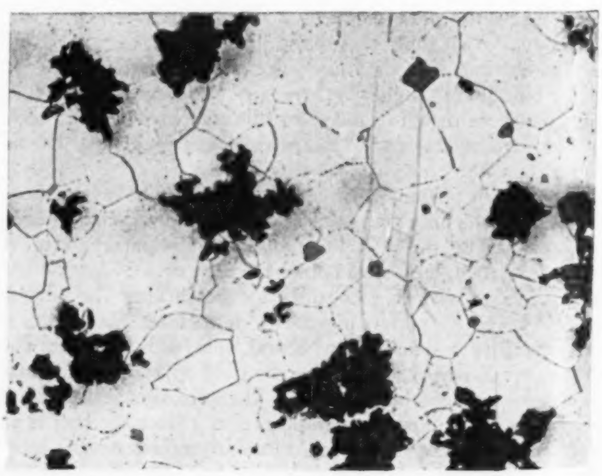
The molds are machined from blocks of soft gray cast iron. Blocks are accurately faced, and the mold cavity which forms the bolt blank is milled. In operation, the mold cavities are coated with acetylene soot from a torch controlled automatically. The torch is mounted above the wheel after the stripping station and preceding the casting, Fig. 1. This soot coating protects the mold and produces a smooth-surfaced casting. A new mold will produce about 5000 bolts before it must be reworked.

HEAT-TREATMENT

The as-cast bolt blanks, of hard, brittle, white iron, are placed on alloy trays and annealed in a continuous pusher-type annealing furnace. The time-temperature cycle each bolt undergoes is approximately as follows: Heat to 1750 F, hold $1^1/_2$ hr, air cool, reheat to 1550 F, cool to 1250 F in $1^1/_2$ hr, and air cool. This treatment decomposes substantially all the combined carbon to produce a true malleable structure, Fig. 4. The air cool from 1250 F is used in order to retain most of the copper in solution; an important factor for best ductility and corrosion



(a)



(b)

FIG. 4 PHOTOMICROGRAPHS OF STANDARD BOLT METAL; ETCHED IN NITAL, ×500

(a, As-cast white iron; cementite, white; and pearlite, gray. b, Annealed; ferrite, white; and graphite, dark. Gray inclusions are manganese sulphide.)

TABLE 1 CHEMICAL AND PHYSICAL TESTS OF STANDARD CAST-IRON BOLTS

Date	Time	Si	S	Mn	C	P	Cr	Cu	Bend $^{1}/_{16}$ in. deflection	Tensile strength, 1000 psi	Bhn
10-14-46	8	3.04	0.082	0.77	2.47	0.10	0.042	0.96	4.2	63.3	187
	11	3.06	0.090	0.83	2.40	0.11	...	..	4.9	61.3	192
	1	3.11	0.093	0.85	2.37	0.10	0.042	1.17	5.6	63.0	187
10-15-46	8	2.86	0.132	0.72	2.48	0.10	0.042	1.31	5.6	67.5	179
	11	3.08	0.093	0.87	2.49	0.10	0.043	1.40	4.2	64.1	179
	1	3.12	0.080	0.90	2.54	0.10	0.040	1.14	4.9	64.6	183
10-16-46	8	3.10	0.129	0.92	2.63	0.09	0.045	1.25	4.0	61.0	187
	11	3.00	0.124	0.85	2.46	0.11	0.046	1.41	4.8	60.7	179
	1	3.10	0.104	0.83	2.55	0.13	0.044	1.18	4.2	58.9	179
10-17-46	8	2.74	0.101	0.75	2.15	0.10	0.041	1.24	4.2	69.0	170
	11	3.10	0.114	0.91	2.49	0.09	0.042	1.06	4.8	64.6	179
	1	3.10	0.071	0.89	2.71	0.08	0.046	1.18	5.6	68.2	170
10-18-46	8	2.89	0.090	0.85	2.56	0.09	0.044	1.50	4.8	62.4	179
	11	2.75	0.081	0.80	2.57	0.12	0.047	1.59	3.8	63.6	187
	1	2.98	0.110	0.87	2.57	0.09	0.046	1.31	5.6	67.3	179
Averages		3.00	0.100	0.84	2.52	0.10	0.044	1.26	4.7	63.9	181

resistance. The annealed bolt blanks are then rattled, gaged, and threaded in production bolt-threading machines.

Nuts are cast in sand of soft gray iron, but with 2 per cent of copper for corrosion resistance. These are annealed at 1600 F to facilitate tapping. The nut iron has a tensile strength of only about 35,000 psi, compared with about 65,000 psi for the malleableized bolt. Many tests have proved, however, that a high unit strength is not necessary for the nuts. Tightening the bolt and nut together in a joint to failure will almost invariably cause the bolt to break in tension before the nut fails.

MECHANICAL PROPERTIES

Hardness and strength values of the bolt metal so produced are considerably higher than those of ordinary malleable iron, because of the effect of the 3 per cent of silicon and $1^{1}/_{4}$ per cent of copper in solid solution.

Sample bolts for test are selected three times in each 8-hr heat. A typical test report for 1 week is shown in Table 1. The tensile test is made by pulling a threaded bolt to failure and calculating the results by dividing the ultimate load by the area at the root of the threads. The bend-test results are expressed in sixteenths of an inch vertical deflection of a $^{3}/_{4}$-in-diam bolt blank on a 6-in. span when loaded at the center through a 1-in-diam pin. This is a simple and useful measure of the ductility of the metal and indicates the degree to which the bolt will adjust itself to unequal loading in a pipe joint. Tests of conventional 0.505-in-diam machined tensile bars have been made on the bolt metal cast in a special metal test-bar mold. A typical tensile load-elongation curve is shown in Fig. 5.

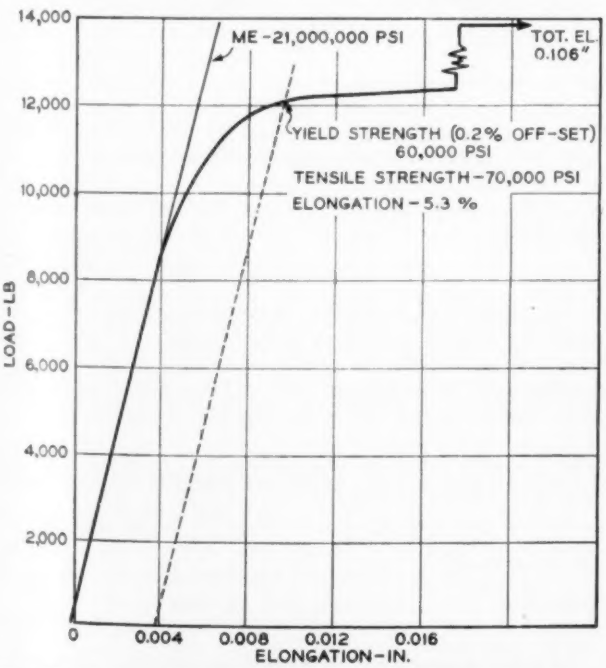


FIG. 5 TYPICAL LOAD-ELONGATION CURVE FOR 5.05-IN-DIAM TENSILE BAR WITH 2-IN. GAGE LENGTH; STANDARD BOLT METAL

The test-bar properties shown in Fig. 5, of 60,000-psi yield strength with 5.3 per cent elongation may be evaluated by comparison with A.S.T.M. A-107-39 requirements for cupola malleable iron of 30,000-psi minimum yield point with 5 per cent minimum elongation. A.S.T.M. specification A-47-33 for regular malleable-iron castings requires 32,500 psi yield point with 10 per cent elongation, while the requirements for the high-strength grade are 35,000 psi yield point and 18 per cent elongation.

In addition to the laboratory tests on sample bolts, the finished bolt-nut assemblies are proof-tested to 50,000 psi in tension. Proof-testing is not 100 per cent but is carried out in accordance with a sampling plan which tests about 20 to 30 per cent of all bolts to maintain an average outgoing quality level of only 1 per cent below 50,000-psi strength.

The good machinability of malleable-structure irons is well known, and it is apparent that this bolt material machines somewhat better than a steel of the same hardness.

CORROSION RESISTANCE

By reason of the copper content in solution in both bolts and nuts, the bolt-nut combinations are slightly but definitely cathodic to unalloyed iron or steel in a conducting environment. This is an important factor in corrosive services, because the electrochemical corrosion currents will run generally from pipe to bolts and not in the reverse direction, so that the bolts in effect are protected cathodically. In strong acids, corrosion occurs more by direct chemical action and here, too, the standard bolts and nuts are more corrosion-resistant than the plain iron with which they are used. The nuts are resistant by virtue of their copper content, and the bolts are more resistant by virtue of copper content and denser structure. Results of a typical test are shown in Table 2. In this test the unalloyed gray iron was sand-cast in the shape of bolts and nuts in order to eliminate the effect of varying shapes of specimens and varying surface areas, and to make the test in so far as possible a true comparison of materials.

Another typical accelerated corrosion test was made by bolting two plain cast-iron bars (cast of normal pipe iron) together

with four bolts and immersing in 2 per cent sulphuric acid for 4 days. The losses in weight of bolts and nuts in contact with plain cast iron are given in Table 3. Presumably the greater resistance of the standard bolt metal is due largely to the $1^1/_4$ per cent of copper in solution.

TABLE 2 ACCELERATED CORROSION TEST OF STANDARD COPPER-ALLOYED BOLT IRON WITH PLAIN IRON

(One week in 5 per cent sulphuric acid; each specimen, one coupled bolt and nut)

Specimen no.	Part	Loss in weight: Grams	Per cent	g per sq cm
1	Standard bolt	10.6	3.4	0.13
	Standard nut	18.5	24.6	0.77
	Total	29.1	7.6	0.28
2	Standard bolt	12.6	4.2	0.16
	Plain iron nut	22.2	30.7	0.92
	Total	34.8	9.3	0.34
3	Plain iron bolt	71.0	22.2	0.89
	Standard nut	20.2	27.2	0.86
	Total	91.2	23.3	0.87
4	Plain iron bolt	61.9	21.9	0.77
	Plain iron nut	32.1	45.1	1.37
	Total	94.0	26.7	0.91
Average	Standard bolts	11.6	3.8	0.14
Average	Plain iron bolts	66.4	22.6	0.83
Average	Standard nuts	19.4	25.9	0.82
Average	Plain iron nuts	27.2	37.2	1.22

TABLE 3 TESTS ON PLAIN CAST-IRON BARS

Material	Loss in weight, per cent: Bolt	Nut
Steel	8.8	50.7
Pearlitic malleable	15.7	40.7
Standard bolt metal (1)	6.6	25.2
Standard bolt metal (2)	4.5	38.6

AUSTENITIC MALLEABLE IRON

A special development of the bolt process is the production of austenitic malleable bolts which are used for supercorrosive conditions or where a higher degree of toughness and ductility is desirable. The metal used is compositionally a modified Ni Resist.[2] The total carbon is kept low and the chromium on the high side.

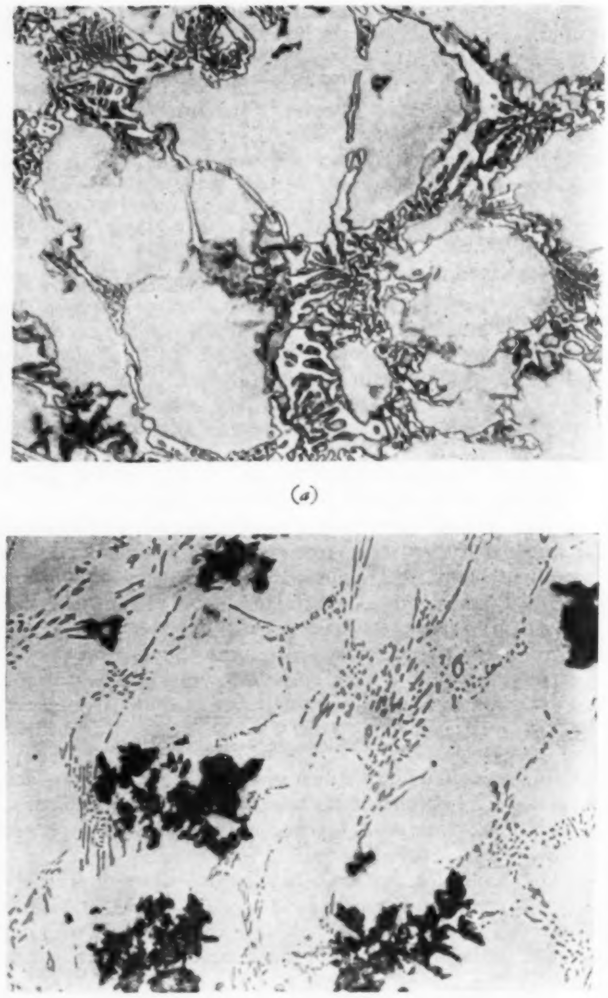
Desired average analysis in per cent is as follows:

Total C	Si	Mn	P	S	Ni	Cu	Cr
2.30	2.00	1.25	0.10 max	0.12 max	15.0	6.0	3.0

This metal is melted in the same 24-in. cupola used for the standard bolt iron and is cast in metal molds on the same bolt turntable. Because of the chilling action of the metal molds, this metal also casts white in sections up to $1^1/_2$ in. diam. Annealing at about 1800 F decomposes most of the combined carbon to produce a soft, tough, austenitic malleable iron, Fig. 6. This metal has a tensile strength of about 70,000 psi, as compared to about 30,000 psi for sand-cast Ni Resist, and significantly higher ductility.

Acipco Ni Resist bolts, especially when coupled with plain iron as in a pipe joint, possess corrosion resistance comparable to that of bronze or stainless steel in most services. Table 4 shows the results of an accelerated electrolytic corrosion test made on joint sections bolted with several types of bolts. This is a very severe type of test. With lower current, or no current, there is a much greater superiority of the last two materials in the table.

[2] Trade-mark, International Nickel.



(a)

(b)

FIG. 6 PHOTOMICROGRAPHS OF STRUCTURE OF AUSTENITIC MALLEABLE, ACIPCO NI RESIST, BOLT METAL; ETCHED IN FE CL_3, ×500

(*a*, As cast; carbides in austenitic matrix. *b*, Annealed; graphite, dark; and carbides, gray; in austenite matrix.)

SUMMARY

Cast bolts for pipe joints are economically mass-produced by use of metal molds and short cycle annealing. The bolts have desirable mechanical and corrosion-resistant properties. An austenitic malleable bolt with unusual strength, ductility, and corrosion resistance has been developed for special services.

TABLE 4 ELECTROLYTIC CORROSION TEST OF JOINTS OF 3-IN. CAST-IRON PIPE BOLTED WITH DIFFERENT BOLT MATERIALS

Bolt material	Loss in weight, per cent: Bolts and nuts	Entire joint
Mild steel (black)	31.0	28.9
Cadmium-plated steel	22.7	28.1
Galvanized	16.1	26.4
Acipco Ni Resist	3.5	27.4
18-8 Stainless steel	2.1	26.4

Electrolyte: 2 per cent NaCl in water.
Current: 0.9 (average) from joint as anode to lead-lined tub as cathode.
Duration: 106 days.

HUMAN BEHAVIOR *in* EMPLOYEE-EMPLOYER *Relations*

By JOHN A. PATTON

PRESIDENT, JOHN A. PATTON, MANAGEMENT ENGINEERS, INC., CHICAGO, ILL.

RECENTLY, we witnessed the paralyzing effect of a breakdown in the nation's communication system, namely, the telephone strike. Less dramatic but just as crippling is the almost unnoticed breakdown in communications between management and worker.

In a recent talk before the Society for the Advancement of Management on the subject of "Recovering Time Losses to Increase Productivity," I explained, as follows, a basic principle of the changing condition of our everyday life, and one which we have apparently lost sight of altogether:

"Management—like it or not—still must carry the main burden of creating and maintaining good labor relations.

"Management still does not fully realize nor understand that years ago when 'driver' tactics were prevalent, a good percentage of our skilled and semiskilled workers were immigrants who had the old caste system in their blood. Today, we have the second and third generations of these immigrants who are now Americans and have been educated to believe that we are all created equal, that the laborer is as much a human being as the president of the company which employs him, and that he should have an opportunity to share proportionately in the combined efforts. Management must realize and have the foresight to appreciate this fundamental change over the past 30 to 40 years if it is to adopt the proper attitude toward labor. Frankly, it has always amused me to hear management say 'we must get the co-operation of labor,' when in reality, if management kept labor informed constantly as to their status with the company, they would not need to solicit such co-operation, for they would have it automatically."

A PAGE FROM AN OLD BOOK

Whether we recognize it or not, our entire way of life has changed tremendously in the past 50 years. The whole concept of personnel relationships has changed. Here is an example of what used to be considered good personnel policy. It is a page from the Carson Pirie Scott & Company employees' handbook, dated 1856:

"Store must be open from 6 a.m. to 9 p.m. the year around. Store must be swept, counters, bases, shelves, and showcases dusted. Lamps trimmed, filled, and chimneys cleaned; bins made; doors and windows opened; a pail of water, also a bucket of coal brought in before breakfast (if there is time to do so) and attend to customers who call.

"Store must not be opened on the Sabbath unless necessary, and then only a few minutes.

"The employee who is in the habit of smoking Spanish cigars, being shaved at the barber's, going to dances, and other places of amusement, will surely give his employer reason to be suspicious of his integrity and honesty.

"Each employee must pay not less than $5.00 per year to the Church and must attend Sunday School regularly.

"Men employees are given one evening a week for courting and two if they go to prayer meeting.

"After 14 hours of work in the store, the leisure time should be spent mostly in reading."

The foregoing thinking is so obsolete now that it's amusing. But maybe our present relationships are just as obsolete and outdated. When the sales clerk was avoiding Spanish cigars, the barber, dances, and other places of amusement, he did know his company and his boss. His job was a large part of his life. You might add that after 14 hours a day, it was about the only life he could have. In contrast, here is a story about his modern counterpart.[1]

This is the story of Joseph Zipotas, but it is no fiction. It is a harsh fact. It is a commentary on management that believes employee loyalty is built on philosophy of "tell them nothing!" A few evenings ago, Joseph Zipotas (name fictional) received his 25-year service pin. Because a 25-year employee ought to know his company well, the publication undertook in a revealing interview lasting two hours, to find out how well Joseph knew it. This is what Joseph Zipotas does not know: The year his company was founded; the number of plants in the company; more than two of the company's products, which exceed two hundred; the name of his company's president (he had been president three years); the location of his company's headquarters; the source of a single raw material; either the operation which preceded his own or which followed it (except in very general terms); what free enterprise is. (He did not even recognize the phrase.)

But this is what Joseph Zipotas does know: The name of his union and the number of his local; the names of two columnists on his union paper; names of three out of five of his union officers; three direct benefits which the union has secured for him (actually the union had secured only two of them, and a third was a compromise); a reasonably acceptable definition of collective bargaining. (His definition: "It's what the union uses to get things for the working man.")

BIG CORPORATIONS OUT OF LITTLE ONES

Let us ask ourselves now what mistakes we as management have made. Starting back in the 1800's, when four out of every five persons were in business for themselves until today, when one out of five is in business for himself or in private enterprise, we have continually been making "big ones out of little ones." One of the by-products of this policy has been the highest standard of living in the world. A second and much less desirable by-product has been the ever-widening gap between employer and employee. That personal contact of top management has continually diminished and in some cases completely disappeared. A somewhat parallel by-product to the second one is that of specialization which must necessarily accompany

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[1] "Company-Union Committee Works Out Job Evaluation Program," by Francis Westbrook, Jr., *Mill and Factory*, vol. 40, March, 1947, pp. 107–110; abstract of this paper appeared in *Management Review*, vol. 36, June, 1947, pp. 318–320.

mass production. Instead of the feeling of creating and building, the individual is now performing operations that have been subdivided into routine jobs of a repetitive nature. These conditions need not exist; yet they do to a large degree. When we ask ourselves, what mistakes have we made, we might answer that in a twofold way:

1 We did not recognize this evolution of the worker in his work. We did not recognize that during the last fifty to one hundred years he was getting to be a clock number and not an individual, as rapidly as our mass production grew with the accompanying standard of living.

2 If we did recognize this evolution of our employees, we surely could not, in general, be accused of doing much aggressively or constructively about it. This is especially evident when you compare it to the intelligent, resourceful, and overall aggressiveness that industry has displayed in producing new ideas in its products, and producing these same products on a large scale. When one stops to consider the brains and combined thinking that were used to produce our war machines, we cannot help but concede that management has really fallen short of its standard of performance as regards employee relations.

LINES OF COMMUNICATION MUST BE REPAIRED

The worker today is still suspicious of the ability of the technological advance to provide more jobs. Workers are poorly informed on such things as where jobs come from, the ratio of profits to wages, or the issues involved in full employment, annual wages, etc. We might ask ourselves, why such conditions of misinformation and ignorance persist, when so much depends upon public understanding of the economic facts of life. The gravity of the situation becomes more obvious when we realize that a well-informed employee has the best chance of being a satisfied employee. He wants to belong. Knowledge of what is going on makes him feel a part of the operation. His sense of security is increased almost in direct proportion to the amount of information he receives regarding the circumstances which bear about him and his particular position with the company.

Until recently the Wagner Act put a damper on the programs for most companies to speak freely and intelligently to most of their employees. However, I am sure now that most companies can feel free to talk to their employees and give them the economic facts of business. From this point on it will take as much effort as that which we put into the miraculous production job in supplying the munitions of war to accomplish the end in which we are all interested, namely, that of having harmonious labor relations. Everything in recent months points to the fact that the lines of communication between management and labor are practically down, and I can think of no problem more serious for our industrial peace than their repair.

We have made mistakes—lots of them. There is no question about that. In summarizing such mistakes, can we not simply say that we as management have ignored the fundamental laws of human behavior, laws such as:

1 Information breeds understanding.

2 We want to be told in advance.

3 We are more inclined to give active support to a program which effectuates a change when we are a part of that program.

After all, it really isn't a problem of finding out who is right and who is wrong but rather to discover and understand the principal facts with which management must deal.

SOME OF THE THINGS THAT NEED PLANNING

If management is sincerely willing to change its practices and attitudes (and to me the attitude of top management determines good or bad labor relations), then we can readily re-establish the line of communication to the company's employees.

The employer who is really sincere about wishing to share information with his employees, knows that the first logical step is to find out what the employee wants to know. This is accomplished today through opinion polls or morale surveys. There is no doubt in my mind that management is becoming more and more aware of the need for such polls, for statistics show that their use has increased 19 times over that of 7 years ago.

We cannot and must not forget that there is competition for the attention of the employee, and he will naturally give it to the most appealing material, whether it be the funny paper, his favorite radio program, or the labor news. Incidentally, the labor press has recently been using comics very effectively to attract the attention of its readers.

The material must be understandable, simple, and factual. We can really appreciate this when we realize that 61 per cent of the people of the United States, 21 years and over, have never gone beyond the seventh grade in school. The trouble with most of us is that we are too likely to talk to the worker with an Oxford accent. Furthermore, letters from most company presidents are usually a mile over the employee's head, using such phases as "fundamental concepts," "arrogant indifference," etc. We forget that what the employees don't understand they won't accept. We forget too that the three musts for material to employees are the following:

(*a*) It must be read.
(*b*) It must be understood.
(*c*) It must be believed.

The material must be correctly timed. During periods of stress and trouble between workers and management, any special attempt to disseminate news is bound to be classified by the employee who receives it, as propaganda; and, in the timing of news, I doubt if one can consider the annual statement as sufficient. In any advertising campaign where the frequency of the impact is so spaced, there are few results.

Although these are some of the guiding principles for opening that line of communication, or narrowing that gap which has developed in recent years, this procedure is not in any sense of the word a substitute for personal contact by top management.

HOW SOME COMPANIES HAVE SOLVED THE PROBLEM

It would be pointless for me to try to develop a pattern for establishing and using the channels of communication to achieve the understanding that is necessary because each company has its own problem and must be treated individually. However, there are certain techniques used by various companies in the successful solution of the problem which warrant emphasis.

For example, let us now look at a company that has done an outstanding job through personal contact. Mr. Stephen Hammond, of the Whiting Corporation, Harvey, Ill., has been holding monthly discussion meetings with his employees since 1937. The company has 1200 employees and approximately 150 are selected at random to meet every month. Participants can and do raise any question without fear of criticism. In fact, the company invites constructive criticism. Management makes a report once a month to its employees and 93 per cent of the employees feel that management gives them true and complete facts. Topics discussed in these meetings are policy, profit-and-loss figures, job costs, and the like.

Another company which has used a different technique but, nevertheless, has also done a very commendable job is United

Air Lines. General staff meetings are held with the nine or ten key men in the organization, headed by Mr. Patterson or his vice-president. Any and all policies are discussed at this time. Following this meeting these nine or ten men have meetings with their supervisors and so on down the line. In addition to this there are regional meetings once a month. To supplement this the company has six co-ordinators who report directly to the vice-president, each of these six individuals constituting a direct line of communication from anyone in the company directly to the vice-president. In addition to this, Mr. Patterson writes a comprehensive news letter periodically. Finally, United Air Lines conducts a comprehensive suggestion conference for continual improvement, and in this way assures a constant influx of material from the bottom up.

Back in 1939 the National Conference Board conducted a contest, and from a very wide cross section, covering 2000 foremen and 226 companies, the results conclusively showed that foremen wanted the following:

1 To be assured of management's support.
2 A chance to contribute their viewpoints and experience when company policy affecting employees is being formulated.
3 More information about the company, its objectives, and its problems.

As far back as 1939 foremen asked for these opportunities. Did we do very much about it? Obviously not, because today we are very much surprised because foremen's unions have become popular.

Let us now look at a company which has done one of the outstanding jobs in convincing its foremen that they are the management. Standard Register in Dayton, Ohio, realizes that in larger companies, particularly to the employee, the foreman is the management. Let us see how they do it. Several years ago they formed a Factory Management Council which operates in the following manner:

Problems are presented to the council by any of the members. The vice-president in charge of operations heads the council. Discussions are full and frank. If many details are involved in a particular problem, a committee is appointed to get the facts. Meetings are every Monday morning for two hours. The foremen are kept up to date on affairs in Washington and on labor developments by a special periodical for foremen, called *Notes and Quotes*. The council also selects men to send to such meetings as National Safety Council; foremen's conventions, etc. Subjects discussed have included aptitude testing, absenteeism, advertising, sales programs, operating expenses, costs, etc.

If you would ask Bill Stein, vice-president in charge of operations, and the man who is largely responsible for this type of co-operative management, "Does it pay, and are we getting results?" the answer would be decidedly "yes."

As a matter of fact, he states that he doesn't know how they could have managed otherwise. Having had an opportunity to serve this company, I would like to add that through this type of training it has one of the highest types of foremen in any company I have had an opportunity to work with.

The story of another company, Wilson Jones, illustrates how complete confidence on the part of the employees can be obtained. Wilson Jones, incidentally, is the world's largest producer of loose-leaf stationery, which establishes it as a business large enough to expect labor-management problems. Many readers can remember not too far back when Wilson Jones was having as much labor trouble as any plant in Chicago. It experienced long and costly strikes. Each year when the new union contract was negotiated, it was a long-drawn-out negotiation, usually lasting several weeks. About a year ago, Mr. M. W. Borders accepted the presidency of Wilson Jones. One of his first acts in the new position was to inform the union representatives that he would provide any information the unions wanted. This year, because of the union's confidence in Mr. Borders' fairness and frankness, and because they knew that information was not being withheld or distorted, the new contract was negotiated in two days. Wilson Jones has had no labor problems while practicing this new philosophy.

Recently, Studebaker, for the first time, mailed a simplified annual statement of business to all of its employees with an offer that if any employee wished a full statement, such as is supplied the stockholders, such a report would be mailed to him upon request.

Every new employee of the Falk Corporation meets members of top management and is introduced to the plant before taking over his duties. Falk's top management spends a great deal of time in the shop and its members are able to call practically every employee by his first name.

At Champion Paper & Fibre Board Company, every new project, such as group insurance, etc., is first explained to the foremen and supervisors.

In a questionnaire given to the employees of Armstrong Cork Company through a cross-sectional sample of workers in a number of the company's factories, employees were asked to state how often they read each of the eleven types of news items appearing regularly in their publication *The Reporter*. The returns were interesting. They indicate that annual and semi-annual financial reports of the company's activities rank next to the bottom in readership interest. This is not an isolated situation, but reflects the general attitude of employees toward the company's financial information.

On the other hand, we see workers making repeated allegations about a company's profit and ability to meet an increased pay scale. The only explanation of this paradox is lack of understanding of the information contained in the reports. According to Mr. Keith Powlison's recent article in the *Harvard Review*, it is conceivable that the disinterest is simply due to the feeling of many workers that they cannot do anything about the financial situation of the company. It is the same sort of hopeless, helpless sense of futility that many conscientious citizens feel about the government or government debts, and that life is too short to worry about it.

TAKE THE MYSTERY OUT OF FINANCIAL REPORTS

Yet, why, in the face of the evidence showing that employees do not understand financial reports, does management continue to prepare and distribute elaborate and expensive reports which are, practically speaking, ineffective, if they were to be judged by the same standards as general advertising is judged?

Perhaps nothing can be done to create an understanding on the part of the worker on the subject of financial reports. Perhaps an employee does not necessarily want to know the company's current financial position before placing confidence in its management. Perhaps the worker is no more interested in these details than we are interested in the details of a doctor's examination and diagnosis. We are not particularly interested in the physiological principles that must be understood concerning a complicated surgery. We just want to know that when something is wrong the doctor is going to be able to fix it.

By the use of charts and other graphic presentation, some companies have done a lot in making financial statements understandable; at least points involving income, taxes, payroll, etc. One of the outstanding jobs along this line has recently been completed by the Jewel Tea Company. This com-

(*Continued on page 749*)

WAGE INCENTIVES *Reconsidered*

By SIEGFRIED J. FECHT

SUPERVISING ENGINEER, GEORGE FRY & ASSOCIATES, CHICAGO, ILL.

THE productivity of industry must be increased if we are to have full prosperity. In order to increase productivity, industry must be given some incentive to do so.

An incentive to industry means an incentive to both management and labor. To the workmen this incentive may be given in two forms, namely, the one under which they get something "nice" if they increase their effectiveness; the other under which they get something "nasty" if they don't.

In our "enlightened" day and age, labor unions and public opinion have of course largely eliminated the second of these two forms of incentive for workers, and fortunately so.

INCENTIVES TAKE MANY FORMS

In the category of nice incentives are not only the familiar wage incentives under which employees are paid more money when they produce above standard, but also those almost forgotten incentives of personal recognition and increased security.

Experiments by the Western Electric Company have proved rather conclusively that recognition can be a much greater incentive to increased effort than money, but we do not use this form of incentive as effectively as we should. At least, we haven't learned to use it in a systematic way.

Increased security in the form of retention of the most efficient workers and release of the least efficient when a reduction of the working force is necessary, is also a worthy incentive; but in how many union plants is management allowed to lay off on a basis other than seniority?

Even with the other forms of incentive available, the most practical incentive is still increased earnings. This may be somewhat less of an incentive than it was years ago, because of the higher standard of living, but an increase in earnings still makes it possible for the worker to buy some of the things he would very much like to have.

Some form of piecework has been in effect since men first agreed to do a certain job for a fixed amount of money, but not until the time of Frederick W. Taylor did employers try to determine, by means of a stop watch, what constituted a fair day's work.

During World War I wage incentives received a terrific impetus and proved to be a means of increasing production effectively.

Between World War I and World War II it seems there was some retraction of incentives. Many employers resorted to the cutting of rates and other bad practices with the result that the experience of many workers with incentives was so unfavorable that the unions wanted no part of them.

When wages were frozen during World War II, wage-incentive plans were applied to step up earnings and increase effectiveness. The War Production Board reported an increase in production of about 40 per cent for an increase in wages of about 18 per cent in those plants where wage incentives were installed.

As a result of the experience with wage incentives during the war, workers and unions are much more inclined to accept a wage-incentive plan. In fact, the United Automobile Workers has organized an institute to train union representatives in time study and wage incentives, and the author's company has installed wage-incentive plans in several plants at the request of the unions.

The general public likewise has a much better attitude toward wage incentives than it had before the war. This is evidenced by the results of a recent Gallup poll which showed that 59 per cent of the people approved of paying for work on a piecework (incentive) basis, and that 75 per cent of those asked agreed that the payment on a piecework basis would increase productivity in most factories.

A SOUNDER BASIS FOR INCENTIVE PLANS

Now that many of the plans, installed during the war, have been operating for several years, it is time that we review them and determine if they should be continued or discarded. If they are to be continued, we should consider the changes which are necessary to put them on a sounder basis.

The results of the installations, namely, the increase in productivity, the increase in wages, and the decrease in costs, are the best arguments for their continuation. Even though wage incentives are not the only incentive, nor possibly the best incentive for increased effectiveness, yet we must admit that so far we have not found any alternative which is much better.

Basically there is nothing wrong with the principle behind the payment for work on the basis of accomplishment; it is in the setting up of the plan and in its administration that management can get itself into a great deal of trouble. Many wage-incentive plans, particularly those installed during the war, have shortcomings which threaten to cause management much trouble unless they are remedied. Among these shortcomings are the following:

1 Standards established from past performance rather than from time study.

2 Standards incorrectly set because of the incompetence of time-study men.

3 No written record of conditions surrounding the job.

4 Provisions for the guarantee of incentive earnings.

These are but a few of the many pitfalls to which a wage incentive is subject. Most of them can be avoided if management will set down a clear definition of its policies on wage-incentive payment and abide by these policies.

MAJOR WAGE-INCENTIVE POLICIES

It is well to consider, at this point, some of the major policies which should be a part of every wage-incentive plan. Each policy should be carefully considered by the company management, a decision should be reached, and a written record should be made of what the company policy will be. A list of policies and their analysis follow:

Employees must be kept fully informed on what is being done with respect to the wage-incentive program. The success of any work-simplification and wage-incentive program depends upon the active participation of all employees. Top management, the supervisors, the union representatives, and the employees

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should be trained in the principles and techniques of work simplification and time study, and their co-operation should be sought.

Presumably modern time-study engineers long ago discontinued making time studies without letting the employee know he is being timed; yet how often is the employee really told why he is being timed? We all admit that no one knows an operation as well as the employee working on it; yet how many engineers get the employee to make work-simplification suggestions on his job?

There is nothing underhanded, secret, or difficult about a good work-simplification or wage-incentive program; so why not make its installation a joint undertaking by everyone, the employees as well as management?

When a new employee is added to the organization, the incentive plan should be explained to him verbally or by a booklet on the subject.

The company must keep its basic wage structure equitable. An incentive plan does not remove basic wage-rate inequities; instead, it exaggerates them. Consequently, the company must first of all make sure that the established basic wage rates are equitable.

Obviously, the best way of establishing fair wage rates and proper wage differentials between jobs is through a job-evaluation program. Such a program evaluates each job according to factors, common to all jobs, affecting the worth of that particular job. It gives management a just measure for appraising the value of comparable jobs.

A survey of industries on principles and practices in time study and wage incentives, made by R. C. Smyth, director of industrial relations, and M. J. Murphy,[1] assistant director of industrial relations, Bendix Radio, Baltimore, Md., showed that 29.4 per cent of the companies covered in the survey did not use job evaluation in determining base rates. It should not be inferred that the rates being used were necessarily incorrect, but if any inequity existed the incentive plan would only exaggerate this inequity.

Employees should be placed on jobs best suited to them. It was one of Frederick W. Taylor's principles that employees should be "scientifically selected and trained," and the application of incentives to plant operations makes this principle all the more important. An employee not qualified to do the work to which he is assigned cannot be expected to "make out" under an incentive plan, and he will not be happy on the job. The company would be doing him a favor and itself a great deal of benefit by transferring him to work which he can perform capably.

The company should schedule production and balance personnel so that employment can be stabilized as much as possible. A wage-incentive plan will not be very effective without a production-control system. Immediately after an employee has finished one job, his next job should be available for him. Supervisors should be able to anticipate the finishing of each employee's job.

By the proper planning and balancing of personnel, the production of each department will be kept on an even keel, thereby eliminating temporary layoffs in any department as a result of differences in the backlog of work. An increase in employee productivity through the installation of a wage-incentive plan will have to be anticipated by the purchase and supply of sufficient materials, tools, etc., on the one hand, and by an increased sales effort, on the other, to dispose of the additional production. Otherwise the wage incentive will fail.

[1] "How Industry Is Using Time-Study Incentives," by R. C. Smyth and M. J. Murphy, *Factory Management and Maintenance Review*, vol. 103, January, 1945, pp. 111–113.

The company must make every effort to place at other necessary work, employees who have been displaced as a result of the work-simplification or wage-incentive program. If the employee simplifies his job, or if the company installs an improved method which reduces the labor requirements, either of which may bring about displacement of the employee, the company must try to place him on another job at the the same or a higher rate of pay. It is only by following such a policy that the co-operation of the employees can be obtained in a methods-improvement program.

Compensation for work-simplification suggestions should be made through cash awards, not through "loose" rates. Those employees responsible for developing the improved method should be rewarded through a suggestion system. Under no circumstances should the employees be asked to "work out" their reward by having them continue their work on a time standard known to be incorrect. Instead, the employee who made the suggestion should receive a cash award immediately, commensurate with the amount of savings the suggestion will produce.

The basic hourly rate should be guaranteed as the minimum rate to be paid, regardless of productivity. The Smyth survey,[1] previously referred to, reveals that 11.8 per cent of the companies studied did not guarantee the base rate. This is not an appalling percentage but this practice can create grievous problems.

Despite the earnings under the wage-incentive plan, the employee should never be paid less than his basic hourly rate. The wage-incentive plan merely offers him the opportunity to earn more than the basic hourly rate, provided he produces above a normal rate.

There must be no ceiling on earnings. In the Smyth survey,[1] 9.8 per cent of the companies still have ceilings on earnings and in three of the companies the maximums were, respectively, 5 per cent above task, 11 per cent above task, and 20 per cent above base rate.

It must be remembered that employees should be paid the full amount of their earnings under the incentive plan, regardless of how high those earnings may become.

Time standards must be guaranteed against any change which reduces the time allowed for an operation, unless there has been a change in the method, materials, equipment, layout, or working conditions. Of the companies in the Smyth survey,[1] 3.9 per cent still do not guarantee their standards against change. How can the employees of such companies have confidence in the integrity of management if the management is unwilling to guarantee its standards? The employees will simply establish a self-imposed maximum productivity and both the company and the workers are the losers.

Management must have confidence in the time-study engineer's ability to set accurate standards of production and must guarantee to the worker that there will be no change in the established standard as long as conditions on the given job remain the same. However, if through an error in the calculation of the standard, either a "loose" or a "tight" rate has resulted, there should be an immediate revision in the standard even though job conditions remain unchanged.

Where there is a change in conditions surrounding an incentive job, the operation is subject to restudy and a new time standard may be established. Important as method study and work simplification are to the proper administration of a wage-incentive plan, only 82.3 per cent of the companies covered in the Smyth survey bothered to analyze the method before establishing a standard on an operation.

Any one time standard applies to an operation only as long as the conditions of that particular job remain essentially unchanged. For that reason, each time standard should be ac-

companied by a layout standard, a materials and equipment standard, and a methods standard. These accompanying standards record in detail the circumstances under which the time standard will apply and give evidence to justify a change in the time standard when conditions change. Only those elements affected by the change in conditions are subject to revision. Under no circumstances is a revision of the standard to be used as a justification for allowing less time for unaffected elements.

Special arbitrary allowances for nonstandard materials or conditions should be avoided. If temporary nonstandard conditions sufficiently affect the standard, the time-study department should, as a temporary expedient, establish a temporary standard effective for the anticipated duration period or for a period of one month, whichever is the shorter. At the end of each effective period the conditions should be checked, and if the substandard conditions are expected to continue, the temporary standard can be extended for another month. A temporary standard which has thus been effective for three months should be established as a permanent standard with the accompanying layout, materials and equipment, and methods standards.

Wage-incentive payments should be made in direct proportion to productivity above the established standard. Payment in direct proportion to productivity is commonly known as a "one-for-one" plan, meaning that for each 1 per cent performance above standard, the employee is paid 1 per cent incentive pay.

Occasionally operations are encountered in which the quality of production is difficult to control. On such operations an incentive paying less than one-for-one can sometimes be used effectively. Wherever possible, however, the one-for-one plan should be used because of its simplicity in calculating earnings and because it is so much more easily understood by the employees.

Again, referring to the Smyth survey, 29.4 per cent of the companies did not pay incentive in direct relation to base rate.

The time standard should enable the normally skilled employee to increase his earnings between 25 and 30 per cent above his basic hourly rate without unreasonable effort. From 25 to 30 per cent is considered a fair reward for operators working at what is commonly known as incentive pace. Earnings above or below this range should not necessarily be construed as out of line, in that they may be the result of abnormal operator performance or chance circumstances.

These figures are quite in line with general company practice. The Smyth survey showed an average of 21 per cent performance above task, but a range from 15 per cent below to 108 per cent above task.

Incentive should be paid only for productivity above normal. It is sometimes argued that a delay in operation is the fault of management and that because of this the operators should not be deprived of the opportunity to earn an incentive rate. On the same basis, however, it could also be argued that it is the fault of management when sales drop off to the point where employees have to be laid off. Very few individuals would contend that management owes the employee incentive pay when he is not at work.

Incentive should be paid only for production over a normal day's work. When a delay forces an employee to be idle or forces him to accept nonstandard work, he may not be producing anything. Nevertheless, he is still given his guarantee of the hourly rate which, if he is producing very little, is a sufficient penalty to management.

This does not mean that the employee is to forfeit any incentive earnings he may have earned on the job prior to the delay. For the delay time he is checked in and out and he is paid separately on day work irrespective of his earnings on incentive.

Occasionally some of the best operators may be taken off regular production runs which are on incentive and given experimental day work requiring a high degree of skill. Inasmuch as these operators would have been working on incentive had they not been given the experimental work, it is hardly fair to ask them to take the penalty of reduced earnings. In such instances the operators should not be guaranteed their past average incentive earnings, however, but should be paid at the evaluated hourly rate for the experimental job. Inasmuch as the experimental work requires higher skill, it is reasonable to assume that an evaluation made of this job would establish the base rate at the proper level. The experimental-work rate would therefore be paid for the higher skill involved in performing the work and not as a guarantee of incentive earnings on what may be a wholly unrelated job.

Incentive earnings should be calculated on a daily basis. Under this plan the employee must average for the entire day more than 100 per cent effectiveness before he earns an incentive. However, the amount of incentive the employee earns one day cannot, under the daily basis, be lost on succeeding days. To pay on periods shorter than one day, such as job by job, might involve too much clerical work. To pay on periods longer than one day, such as the week, might penalize the employees by taking away some of the incentive earnings for one day to balance low performance for succeeding days.

The Smyth survey reports that 27.5 per cent of the companies are calculating incentive earnings on a weekly basis.

Of course there are instances in certain industries where a job may last, not the usual 2 or 3 hours, but may continue over a period of 2 or 3 days. Obviously, a fairer basis for wage-incentive payment here would be by the job basis rather than the daily basis. But in the normal plant where the average job lasts 3 hours or less, the daily basis of calculating is the most equitable.

The incentive plan should be on a standard time basis, not on a money basis such as piecework. The standard time plan expresses the production standards in terms of standard minutes or standard hours for each unit of production. The earnings are calculated by multiplying the total number of units produced by the standard time for each unit to give the earned hours. The earned-hours figure, in turn, is multiplied by the worker's hourly rate. An effectiveness percentage may be calculated by dividing the earned hours by the actual hours worked.

Although in the Smyth survey 35.3 per cent of the companies are using piecework, the standard time plan is to be preferred in most instances for the following reasons:

1 Time standards are not affected by basic hourly rate changes.

2 The effectiveness figure offers a simple means of comparing the performance of individuals, departments, and plants.

3 Incentive standards are independent of hourly rates.

4 Individual hourly rates within the rate range for each job can be reflected in the wage-incentive payments..

The only major disadvantage under this system is that the standard cost calculations may be more involved unless advantage (4) is to be overlooked, and the hours earned multiplied by an established rate for each job.

The incentive should cover as many operations as practicable. In the Smyth survey the range of percentage of direct labor hours covered by incentive was from 30 to 98 per cent, with an average of 71.8 per cent; while an average of only 12.3 per cent of indirect labor hours was covered by incentive.

The incentive plan should be extended to the indirect workers as well as to the direct workers, because in many instances where the direct workers are put on incentive, the indirect workers serving them are required to work faster. If the indirect workers increase their productivity, they, too, should be given an opportunity to earn an incentive. Incentives for indirect workers should be based upon the performance of the indirect workers as well as the performance of the direct workers whom they serve.

Standards must be established through the use of time study. Of 49 plans installed with the co-operation of the War Production Board, 55 per cent were installed using past performance as a basis for establishing the standards, whereas only 41 per cent were installed using standards established from time studies.

The establishment of standards through the use of systematic work measurement, that is, recognized time-study procedures, precludes the use of standards established by estimating or by averaging past-performance figures. It does not exclude the use of standard elemental times which have been established through proper time study, nor does it exclude the use of formulas for calculating machining times using recognized speeds, feeds, and depths-of-cut figures.

Production must at all times meet specified quality standards. Incentive is paid for production of proper-quality work only. If an employee, through negligence, spoils materials or parts, this spoilage is not counted toward incentive production. Quality standards should be incorporated in the materials and equipment standards, and the work done by employees on incentive should meet these quality standards; otherwise the time standard does not apply.

On line or group operations where a group standard is being established, time should be allowed for enforced idleness. In group operations where everyone does essentially the same work or where all employees pitch in and do whatever work there is to be done, no enforced idleness exists. On the other hand, if each employee has a certain function to perform at which none of the other employees can help him, the pace of all other members of the group will be limited by the longest operation. Separate standards should be set for all operations, but a balancing delay time, sufficient to bring the total time up to the total time for the longest operation, should be added as a subsidy to the shorter operations.

In establishing standard times for machine elements, an allowance should be added which will make it possible for an employee to produce 25 to 30 per cent above normal. An incentive allowance should be given only on those elements where the operator cannot reduce his time beyond a specified figure because of machine capacity. If this allowance were not given it would be impossible for the operator ever to earn the desired incentive.

CONCLUSION

Underlying these policies is the urgent need for an incentive in order to increase the productivity of industry. In discussing these policies the author has pointed out what the nature of the incentive may be. There are incentives which could be and someday may be used as effectively or even more effectively than the wage incentive. Until then a wage incentive is a satisfactory means of increasing productivity, provided of course certain basic policies are followed in its conception, installation, and administration.

Our experience indicates that the policies outlined bring favorable results. However, it is vitally important that management formulate what its policies will be, put them into writing, make them known to those individuals who will be affected, and then abide by them.

Human Behavior in Employee-Employer Relations

(*Continued from page 745*)

pany prepared a talking slide film which presents the financial side of its operation, in terms which are most readily understood.

THE COMMON DENOMINATOR

There is no doubt but that the companies mentioned in the foregoing examples are leaders in their several fields, especially regarding labor relations. They seem to have found the secret ingredient. Yet they all differ in the programs they follow. The question is: "What is the common denominator?" To me, the common characteristics are as follows:

1 Top management has recognized the importance of the individual and above all has convinced him of it.

2 The programs allow the employee to be heard, as well as management.

3 Instead of making it a one-man job, they have made it the responsibility of every executive, supervisor, and foreman.

4 Each program has been a continual job, utilizing every available means to get it across, including meetings, pictures, magazines, and newspapers.

Stating it in another way, the secret of a successful employee relationship is a sincere desire to do a job, backed up by concentrated effort of every management man.

CONCLUSION

I don't believe that the right relationship between the worker and his boss can be achieved overnight or in a year, because of the sheer number of misunderstandings, misconceptions, and uncertainties which cause the rift. It is a full-time job for every management man to apply the principles of human engineering in his daily work. Only when such concentrated effort is exercised can the trend be reversed and the road to harmony found.

An absolute understanding and harmony between company and company employees is asking the impossible, because we will always have differences—differences in objective or opinion, just as we will have such differences in matters of religion or politics. A mutual respect and a worker's belief and confidence in management are possible, however, and that confidence is needed if we hope to reconcile our differences. When all parties have confidence in each other, to the point where everything can be discussed and divergent viewpoints reconsidered, we will have completed the foundation for industrial peace.

Today's Pattern of INDUSTRIAL RELATIONS

By RALEIGH W. STONE

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A POLL of opinion on the question: "What is the central issue in the current and prospective pattern of labor relations?" would result in a high degree of unanimity of opinion among groups of people of all types. Businessmen, legislators, union leaders, rank-and-file workers, reformers, and academic students would probably agree that the central issue in the current pattern of labor relations is the question of what to do about unions.

A year ago would have found popular opinion not only highly unanimous respecting the essence of the problem, but also with a high degree of unanimity of opinion as to just what should be done about it. The simple answer would have been to put a bridle with a curb bit on the unions and to rough-break them to a co-operative form of behavior, that is, in the light of a popular conception of "co-operation," to teach them to coo while the economic system operated. As will be recalled, President Truman's voice for drastic curbing action a year ago led all the rest, but as soon as the railroad fire was out, he cooled off enough to veto the Case Bill. Despite this backing and filling, on again off again, behavior of the President, the popular state of mind which called for a drastic curb on unions was kept alive by John L. Lewis, and the fear of a new round of strikes in basic industries in 1947. With absence of crippling widespread strikes this year, the popular demand for union curbs has so disintegrated that President Truman, because of political expediency, vetoed the compromise bill recently enacted by Congress.[1]

Thus, we find ourselves in a hopeless state of confusion. It is still the popular notion that what to do about unions is the heart of the labor problem—both currently and for the future—but there is no longer any consensus of opinion as to what can or should be done about them.

INDUSTRIAL RELATIONS—A POLITICAL FOOTBALL

The growth of unions and the expansion of Government in the field of industrial relations has made these institutions ends in themselves rather than means to ends. Unions are more concerned with aggrandizement of the power and prestige of the unions and their professional leaders than with constructive action to improve industrial relations; likewise with Government which is more concerned with the effect of action on blocks of votes than with the question of improving industrial relations. In other words, industrial relations has become a political football—both in union and government politics.

Several difficulties follow from this. It is, for example, the very essence of political action to harp on and magnify differences of interest, whereas under a free-enterprise system a constructive pattern of industrial relations must operate to minimize differences by serving to the maximum degree the mutuality of interests. Then too, a political approach, as indicated, results in preoccupation with details of method rather than concentration upon the basic problems themselves. Unionism and Government obviously cannot be the basic labor problem; these are at most only agencies or methods of dealing with the problem. The problem is something else which is largely lost sight of in our quibbling over ways and means which have become ends in themselves. Progress in the years ahead depends upon our developing a better analysis and understanding of the problem itself and, in the light of this understanding, developing a plan of action that will command confidence and support because of its promise of providing a constructive approach to accepted goals.

In such a program of action there will be a place for Government and for unions as well as private management, but in a free-enterprise system the basic guidance and controls must be exercised by free markets. However, free markets are not enough, markets must be not only free but technically efficient. The role of Government and unions is that of promoting, supplementing, and complementing free markets rather than supplanting, restricting, or interfering with them. The future of industrial relations depends not upon eliminating Government and unions, but rather, in the light of a more adequate analysis of the labor problem, to determine and assign the proper roles to Government, unions, and management in a co-operative, constructive plan of action.

WHAT IS THE LABOR PROBLEM?

The first step toward such a co-operative constructive program is an adequate statement and understanding of just what the labor problem is. In its basic elements, the labor problem is fundamentally the same problem with which we have been wrestling for the last 150 years or more. Details change, and there have been changes in degree from time to time, but the fundamentals of the problem are the same. As noted previously the biggest changes are not in the nature of the problem itself but in our notions and actions respecting ways and means of dealing with the problem. The major changes come from our heads in the form of bizarre, false, and contradictory assumptions, theories, and notions of what to do about the problem.

Simply and succinctly stated the labor problem is the problem of making effective use of the human resources in a free society.

This definition of the labor problem has one slick word—"effective." As engineers well know, efficiency or effectiveness is a ratio—the degree of efficiency being measured by the size of the ratio. In the physical world, the world in which engineers operate, efficiency is the ratio of work done to input of energy. This engineering test is an element but only one element in the effective use of labor. The productiveness of labor is the determining factor in the possible standard of living. Technical efficiency is also a kind of religion; worth-while workers do not like to work under inefficient technological conditions. Although they resist technological change in all manner of ways, they nevertheless prefer technically efficient

[1] The Taft-Hartley Bill was subsequently passed over the President's veto.

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machines and ways of doing work. Progressive improvement in technological efficiency is a necessary factor in any solution of the labor problem; *solution* in the sense of moving constructively toward the goal of more effective utilization of labor. But the engineering test is not the controlling test of effective utilization—a fact which engineers too often either forget or do not understand. Labor is a productive factor, a mechanism for doing work, but it is more. The labor problem involves engineering tests but predominantly it involves human values, and if there is any getting along to do engineers will have to make the accommodation.

In a pecuniary society the dominant test of effective utilization of labor must of necessity be the economic test. Here we are concerned with the ratio of input of dollar expense to the value product in dollars. Even Joe Stalin cannot dodge this test with his system, but he simply resolves all questions in dispute by liquidating the opposition. Economics is concerned with human values. It is the defensible assumption of a free-enterprise system, controlled by free and efficient markets, that the prices established for goods and services are correct and reliable measures of the relative values placed by people upon these different items of goods and services. However, there is a divergence between this assumption and actual practice because (1) our markets are not technically free and efficient, and (2) a contract for the sale of labor is not a complete specification of the contract; too many matters of importance to both workers and management are of necessity not specified. A contract for work is in large measure an act of faith. Although this statement points a line of action toward solving the labor problem by making all markets, and especially the labor market, more free and more efficient, this would not take care of the human values which do not gain expression in the labor contract, because it is literally impossible completely to define and specify them. This brings us to a third type of test of effective utilization of labor.

Work is a way of life as well as a source of livelihood. A way of life involves the whole man, not merely the calculating, rational, economic man. Moreover it brings in, to different degrees, the family and community interests and notions of a good way of life. In large measure these values are sentimental, nonrational rather than rational. Conflicts arise on grounds that are more imaginary than real between the more or less nonrational "way of life" test, the strictly logical engineering test, and the more or less logical economic test of effective utilization of labor.

An effective approach to the labor problem requires therefore not a compromise but an effective synthesis of these three different tests. The dominant test in a free economy must be the economic test. The first line of action then is to make the economic test more effective and complete by action to make our markets, particularly the labor markets, more free and efficient. This line of action will greatly reduce and simplify issues now comprised in the "way of life test" and should make possible a workable reconciliation between the "way of life" and the engineering tests, and an integration of these tests with the economic tests.

What I am suggesting is that engineers must become social philosophers, and that they must learn to practice their profession in the framework of an acceptable social philosophy.

The major problem for the future of industrial relations is the widespread loss of faith in and dependence upon control through the action of free competitive markets. The oft repeated phrase, "Leave it to competition," has a hollow and unconvincing ring. Few know what the phrase implies or take it seriously. Instead, most people are demanding coercive action; coercive action by the state, by unions, or by employers. Different groups favor different types of coercion of course, but the approved method of control is coercion rather than free markets. Through coercive methods conflicting groups are demanding and expecting to get more net advantages than a competitive market would yield. Thus, the labor problem, along with other economic problems has degenerated into a struggle over conflicting objectives and methods of coercion.

EFFECTIVE UTILIZATION OF LABOR

A plan of action toward a more satisfactory system of future industrial relations calls for a more detailed specification of effective utilization than has been presented thus far. In terms of goals and lines of action, the following points are submitted as a working platform for effective utilization of labor:

1 Reasonably regular and continuous employment at high levels.

2 Employment at tasks commensurate with ability to work.

3 Employment conditions conducive to the development of native capacities and interests.

4 Employment conditions conducive to the development and conservation of physical vigor and well being.

5 Conditions conducive to the development of personality and preservation of the integrity of the individual as a person.

6 A mutually satisfactory method of sharing the remaining burden of employment risks.

7 Wages: (*a*) The minimum requirement for health and efficiency. (*b*) Pay equal to marginal value product.

These goals and lines of action are submitted as an adequate and comprehensive statement of the labor problem. In proportion as they are attained, the labor problem will disappear. Workers would be receiving both as a way of life and in economic reward the maximum attainable; business would be well served, and the public interest fully served. Were I to ask, as I do students, whether this statement of the labor problem represents the worker, the employer, or the public interest, I should get every variety of answer; and all answers would be right. It represents each and all of these interests generally thought of as divergent or opposed. This trick is accomplished merely by stating the problems in positive terms, thus centering attention upon common-interest grounds rather than upon differences, which would in fact be minor in a free society.

This statement of the labor problems performs three positive services to understanding, i.e., (1) it points the lines along which action must be taken to make future progress in industrial relations; (2) it provides a basis for the proper allocation of responsibility for constructive action as among Government unions, and management; (3) it provides a basis for ascertaining the basic causes of labor problems, and for an appraisal of progress or failure to date.

The seven points listed as constituting the labor problem are not of equal importance. Point 1 is the basic labor problem. Until a worker dependent upon wages for a living has a job, he can have no other labor problems. Only if he has a job is he in position to enjoy the luxury of wanting the job to be better in the other respects indicated. Point 5 (conditions conducive to the development of personality and respect for personal integrity) is next most important. This is the heart of the "way of life" test of effective utilization. No attempt will be made to rank the other points, except to state that point 7 (wages) should be the least important point instead of the most important as at present. The only reason why the wage issue dominates all others at present is that we are trying to solve all the other problems by means of wages instead of approaching these problems directly by more appropriate methods. This of course makes utterly impossible the satisfactory adjustment of the wage problem. There are some elements of human value that cannot be bought with wages.

BASIC CAUSES OF LABOR PROBLEM

The statement presented indicates three basic causes of the labor problem; there are other causes of a minor or secondary character, but three causes are controlling. In order of importance these sources or causes of the labor problem are (1) cyclical fluctuations in production and employment; (2) an ineffective labor market; (3) specialization and division of labor with the accompanying structural and technological changes. Other factors contribute to the labor problem, but with these sources of difficulty under control the remaining labor problems would be relatively simple.

Cyclical fluctuation is the principal cause of failure to maintain continuous employment at a high level, and is the principal cause of government and union efforts to attain job security in all sorts of devious ways which interfere with effective use of labor. This is also the major factor in current wage policy. A new but totally absurd wage theory has become widely accepted in government, union and, yes, in management circles. A theory that wages increase purchasing power more than they increase costs, so that higher wages expand employment. Thus, wage increases are always in order either to expand employment or to prevent deflation. President Truman "rides that horse" as did President Roosevelt. Read the preamble to the Wagner Act and read President Roosevelt's message to Congress in support of that act and one will discover that the primary objective of the act was to build powerful unions to raise wages and promote business recovery; it was only incidentally an industrial-relations measure. Major problems of wages, hours, and job control, as well as continuity of employment all stem back to cyclical fluctuations. Every item listed in the previous seven-point statement is affected by cyclical fluctuations in employment. Could we find a way to eliminate or substantially dampen cyclical fluctuations we would by that single stroke eliminate fully half of the labor problem as we now know it.

However, cyclical fluctuations are almost if not entirely beyond the control of the individual company. Likewise they are a problem entirely beyond the control of unions. The net effect of union action is to make cyclical fluctuations more severe. This problem clearly rests with Government. Its correction or mitigation depends upon two lines of government action; i.e., (1) measures to improve the technical efficiency freedom and flexibility of our market structures, and (2) government fiscal policy to promote stability.

The ineptness of government policy and action to date respecting cyclical instability does not encourage us to judge that this basic cause of labor problems will be dealt with effectively in the future. Not only do we need a completely new and sounder theory, but also we must somehow take the problem out of the game of political football. It isn't the sort of problem that can be handled by pressure politics.

Frequently the remark is heard from businessmen that the next depression will teach labor some sense. That is a bad guess. General unemployment would only bring on another fear and frustration complex which in turn would press Government and unions to renew and expand all manner of stupid or bizarre coercive expedients. Business leadership and free enterprise would only be further undermined.

The present labor problems, in the face of present high-level employment, are largely a hang-over from the psychotic fears and frustrations, and the institutional "New Deal" expedients and notions which were a reaction to the deep, long-continued unemployment of the 1930's. To see in historical perspective the effect of frustrating unemployment, just compare industrial relations in two comparable periods of high-level employment—the 1920's and the 1940's. In the 1920's unions were falling to pieces, government action was practically nil, and employers were hunting for labor problems. Not so today. The fears and frustrations generated in the 1930's produced the New Deal, built up the present union movement, and left not only workers but also employers with a fear psychosis which still persists and affects attitudes and conduct. Only long-sustained high-level employment can dissipate these fears and make possible a more rational, more constructive program of action.

MANAGEMENT CAN HELP REDUCE SEASONAL FLUCTUATIONS

The point was made that individual company management has little if any control over the principal cause of labor problems; namely, cyclical fluctuations. But there are other causes of lack of continuity of employment over which management can exercise control to a degree that is important. By better or different planning, management can exercise some control over seasonal fluctuations. Technological change and its effect on employment are entirely within the control of management. Probably still more important is the employment instability reflected in quit and discharge turnover rates. Quits and discharges are almost entirely a function either of ineffective recruiting and selection, or of faulty handling subsequent to hiring. In a tight labor market, really effective selection is not possible but that limitation will rapidly decrease in the months ahead. I do not foresee any significant business depression in the several years ahead, but labor supply will be easier anyway. Between two and three million workers are now engaged in expanding inventories. Since inventories should not and probably will not expand much beyond present levels, from two to three million workers will be free for other work. Also the heavy investment in tools and facilities during the past 18 months will make possible the same production with fewer man-hours.

Management will have few excuses in future months for failure to bring under substantial or complete control the minor but important causes of employment instability just listed. These are precisely the types of employment instability about which the unions are bargaining, and which they are trying to control by rules governing such matters as hiring, apprenticeship, layoff, discharge, promotion, technological change, job allocation, severance pay, and the guaranteed annual wage. Management has been negligent in permitting unions to take the lead on these matters. These are important issues to workers, they are largely or substantially within the control of company management, so that clearly it is management's responsibility to exhaust the full possibilities for effective control over these causes of employment instability.

LABOR-MARKET PROBLEMS

Consider now the second, third, and seventh points in our statement of the labor problem, namely, jobs commensurate with abilities, conditions conducive to the development of capacities, and wages equal to marginal productivity. These problems are secondary to continuity of employment, but they are important. Management of the individual enterprise has a substantial control and responsibility for making progress toward these goals, but its control is only partial. Basically these are labor-market problems, and employing companies taken as a group form only one side of a market—the demand side. The supply side of the market is largely outside managerial control. Moreover the individual company is typically only a small part of the demand—each company having a limited range of types, grades, and number of job openings. To meet the goals of jobs commensurate with capacities, and full opportunity for development, workers need effective access to the total range of job possibilities and not merely the limited opportunities of a single company. Likewise, to assure the best labor supply, employers need effective access to the total

labor resources in the labor market; the presently employed and potential workers, as well as the unemployed.

Individual company managements have made notable progress in developing personnel management policies and procedures to handle more effectively recruiting, hiring, placement, training, and personal-relations and adjustment problems. This is all to the good as far as it goes, but it doesn't go far enough. Good personnel programs have certainly been of major value to companies in carrying on the work of the individual company more effectively, and they have rendered most valuable service to the employees of the companies. But these individual-company programs are limited by dollar and cent calculations of their value to the company. Some of their good work "slops over" of course to serve the community—but it only slops over. Individual companies cannot and do not consciously or by design assume any responsibility for the total labor market. The individual company merely looks after its own employees, and when it hires a man the typical procedure is to try to convince him that this is the only employer in the market, and that he is committing himself for life.

PERSONNEL MANAGEMENT IS NOT ENOUGH

Personnel management is all to the good as far as it goes. But if all employers had the best possible personnel programs we still would not have a technically efficient labor market, capable of discharging the control and service functions necessary to a free-enterprise system. Workers and potential workers in any labor-market area would still lack adequate information about the total range of job opportunities—the number, location, working conditions, skill and other abilities required, rates of pay, training and development prospects, job stability, and the precise steps to be taken to prepare for and to get the best job for which he is fitted or for which he has capacity.

Employers would also still be inadequately served because the best possible company recruiting plan cannot give a company effective access to the full range of potential labor supply in the labor-market area—I mean those workers who are employed by other employers to whom better jobs could be offered, as well as the unemployed, and the prospective workers. The public interest would continue to be poorly served because labor resources would be ineffectively allocated, thus holding down production and the standard of living. Wages would continue to be inflexible and there would continue to be no assurance that the going rates of pay would have any close relationship to the value of services rendered. Employers, workers, and the Government would continue to distrust the wage structure. Management would still lack effective guidance and a solid foundation for wage and salary administration. Government would be pressed to retain and expand wage-and-hour regulations, and unions would continue to have a field day setting wage rates on the basis of coercive power; so-called "collective bargaining."

Good personnel management on a company basis is not enough. What is called for? In every labor-market area (an area in which workers commute daily to and from work), we need a central labor-market agency. This agency would have the following functions: (1) To maintain a current catalogue of all potential and actual workers in the area—names, telephone numbers, addresses, present job if employed, work experience, skills and abilities, personability factors, interests, rate of pay, etc., in short, all obtainable pertinent information about labor supply; (2) comparable current detailed information about all the jobs in the area, that is, a complete current picture of labor demand; (3) studies and analyses to indicate currently market operations and trends; (4) an information service to make this information readily available to all interested parties; (5) a central clearing house or market place to facilitate transactions; (6) a market policy that would fill jobs with the best worker interested, irrespective of whether he is currently employed or unemployed; (7) this market service to be directed by the best sales manager available, with the understanding that he is to operate a market and not a social-service agency. What I am talking about is something like the cash grain markets or the money markets, two of our most efficient types of markets.

Such a labor market would require the full co-operation of employers both in patronage and in supplying job information. Interest in better service would provide a strong positive inducement but I suspect there would need to be some compulsion. Employers would probably be required to file at appropriate intervals manning table reports cataloguing jobs, work force, training, upgrading schedules, and hiring plans. Employers would be required also to list job openings with the market agency, and make detailed reports on all hirings. Such compulsion should be held to a minimum but in any case it would be preferable to a condition which renders inadequate service, and consequently supports and invites further inept coercive action by trade unions and Government, and threatens to break down the free-enterprise system. The compulsion suggested is only the cost of being free and efficient. We do not want more Government in business, but to avoid this we need have more efficient government around business.

With the support and extension of the kind of labor market I have outlined, personnel management could do a real job; without such complementary service personnel management is incompetent to do a complete, constructive job.

With the exception of a minimum insurance of employment risks which, properly, the Government has taken over, the other items in the labor problem lie largely within the control of management, and to its credit management is doing an excellent job. The accident, health, and working-conditions programs of management are progressively constructive. Also management is rapidly learning the importance of good constructive human relations and is improving procedures to that end.

The two glaring gaps in our labor program which by virtue of their pervasiveness and importance tend to reduce other elements of personnel management to naught are, as already indicated, cyclical fluctuations, and an ineffective labor market. These problems lie largely outside the control of management, yet they are the controlling causes of the labor problem. The prospect for better industrial relations depends upon employers co-operating with each other, and guiding and co-operating with the Government to achieve constructive action on these problems.

ROLE OF THE UNIONS

In the foregoing have been discussed the roles of Government and private business management in dealing with the labor problems. Reference has been made only incidentally to the role for unions. In my judgment the constructive role of unions is decidedly limited. Government has delegated to them far more coercive power than it is safe or proper to permit any voluntary group to exercise. Unions are private clubs exercising under legal sanction coercive power both directly and politically to gain advantages for their members at the expense of nonmembers. There is a limit to how much of that sort of thing is either good or endurable. The case for unionism, in so far as a case can be made, stems, however, from the defects and shortcomings that we have been discussing—unstable and uncertain employment, limitations respecting work opportunities, an intolerable burden of risk and uncertainty,

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Putting MANAGEMENT'S HOUSE *in Order*

By PAUL K. POVLSEN

VICE-PRESIDENT, MOTOROLA, INC., CHICAGO, ILL.

FRANKLIN D. ROOSEVELT said it: "The Bourbons learn nothing and they forget nothing." And by Bourbons he meant all of us. Perhaps he was right.

At least, if we learn we learn very slowly. Some company managements haven't learned yet that the war is over, and they'd better shrink down the front office and make the people who are left go to work. Others, not forgetting the 1931 period and sensing a similar period coming, are firing and cutting and otherwise acting like scared rabbits. When will we learn to be men—men who try to run a balanced business, whether the times are good or bad? When will we stop acting like profligates in good times and acting in bad times as if the world were coming to an end? "When times are good they'll never be bad, so let's give 'er a good ride! When times are bad they'll never be good, so let's cut out all research and development! Let's stop thinking and trying! Don't let's try to do anything but bend with the wind!"

Oh, yes! there are problems today, plenty of them; and the world is indeed sick, but it isn't going to get better till we give it at least a large dose of balance and courage.

WHAT CAN BE DONE ABOUT INDUSTRIAL PROBLEMS

Here are some of the things I think we can do about it:

Let's give all the people in the business a chance to contribute to it. In other words, let's stop trying to be little Caesars who know all, see all, hear all—and understand nothing. Let's get everybody into the act and stop being impressed with our own importance and dazzled by the reflection from our own brass hats. There isn't a man who reads this who, if he has even one subordinate, is solely responsible for his own business fate. That fate is in the hands of the people whom he thinks he's responsible for, when as a matter of fact he's responsible to them. He has a deep obligation to them; and he had better learn that each and every one knows more about his and her job than the boss, and collectively they can make or break him. So be good to these people. Particularly give them an opportunity to show you and management what they know and in turn you tell them what you know—all of it. Do this in a regular way through junior boards of directors, as originated by McCormick and Company in Baltimore and used by 500 other companies; and through advisory boards to give information to and get suggestions from the individual employee, as does Lincoln Electric Company in Cleveland. This is the paramount recommendation of all. The day of the superman in industry is through. Business is too complicated. Good men are needed at all levels, and they must be informed people—people with a voice, and an interest and enthusiasm in their business. Keep the lines of communication open both ways—up and down the line. Use alternating current and keep the lines always open.

Let's get good men in each job at all levels. We can make sure we have good men through wisely chosen tests such as interest, aptitude, and personality inventories. It should be clearly understood, however, that these tests are merely tools to supplement personal knowledge, judgment, and performance on the job. Give these tests to all existing supervisors and to prospective supervisors before they are appointed, and to any supervisor before he is promoted to a higher rank. Don't depend upon one man's judgment, or whim, or hope in hiring and promotion. Promote from within the business when it can be done, but when definitive tests show conclusively there isn't a man who can fill the bill, get him from the outside, but give him the tests too before hiring him. Such men cannot be hired ready-made from a mail-order house. You've got to develop your people. Start with what you have, build and develop, and move up, down, and sidewise. A team really working together is stronger than any individual, and any individual's satisfaction is bigger than his own job. It's as big as the team.

Let's make sure the organization setup is clear, definite, and on paper, and then streamline it. Nothing is so disruptive to good working efficiency as overlapping responsibility, or a vast no man's land where nobody is responsible. Define the responsibilities in writing from the president down. Let each man know what is expected of him and then hold him strictly accountable. The purpose of a good organization is to allow good men to operate properly, but good organization won't overcome poor men, and good men can overwhelm poor organization, but it isn't desirable. The best combination of course is a streamlined organization with a good man in every spot.

So, having put the right man in the right job and streamlined the organization, giving each man authority as well as responsibility, let's learn how to live together on fundamentals.

Let's get honest in our dealings with our employees, our customers, our stockholders, and the public. Let's not be technical and sharp. For example, if we have piece rates, let's set them as honestly as we can and then keep them in effect, unchanged, regardless of the individual's earnings.

Let's not have a piece-rate cutting bee at the end of each year. Let's give our customers an honestly designed, well-built product.

Let's regularize employment. Of course there's a lot of bunk, talked by both management and labor, about the guaranteed annual wage. There are some companies which have found a way to regularize employment throughout the year. Other companies when asked to do this, talk about the fact that their case is "different." As one estimate has it, 80 per cent of the firms could do it. I think it is up to all of us to see how we could possibly make some approach to regularizing employment rather than finding reasons why it can't be done in our business. It has been pointed out that management puts itself on a year-round pay roll and the lesser-paid individual employees certainly deserve every consideration to see what can be done in this direction in their belief. Dollars can't be weighed against fear of unemployment and uncertainty. There may be much to the fact that there is a lack of effort on the part of workers so that they won't work themselves out of a job.

Let's learn to live with unions. Originally unions came into existence because employers were greedy and thoughtless of human misery. Now many companies have them though there is no good reason why they should have them. But whether we deserved them or only got them because of the trend, now that we do have them we must learn to live with them. Edu-

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cate them in economics, time study, production procedures, and processes. Don't forget the union people are your employees even before they are union people. Channel this force. Your business is your people and they alone can make it; the machinery cannot.

Let's give industry back to the people who know how to run it. During the last several presidential terms, business has literally frothed at the mouth over the centralization of power in the hands of the Federal Government They wanted the Government given back to the people. O.K., how about a little consistency and give business back to the people? Let's stop trying to make decisions for a whole nation in Washington and for a whole industrial empire in New York or Chicago or wherever "Headquarters" is. If we want to fight tyranny, let's fight all tyranny—tyranny of government, tyranny of big business, tyranny of labor unions. Let's set up plants of a size such that a human being can understand and get close to his people. Let's run these plants for the good of the employees and the community in which the plant is located, as well as the customer and the stockholder. Don't let's have blanket orders out of Headquarters whether they make sense locally or not, and blanket union contracts covering a whole company, with plants all over the country, or a whole industry, whether they make sense locally or not. Give labor negotiations back to the people who have to live together—local management and local employees—without high-priced, high-pressure lawyers on either side getting legal and technical and forgetting that two groups of humans are trying to understand each other and live together in peace and harmony.

Having picked our people for the right spots, properly organized them, and having learned to live together agreeing on fundamentals, let's have the discipline necessary to function as a great team.

Let's have a salable product according to the public's acceptance. We must put our product under a microscope in the hands of cold-blooded business analysts. Our products are somebody's brain children in the business, who will fight at the drop of the hat and to the last drop of blood for their babies. They can convince themselves and too often top management, that it's a good product. The falling sales curves? Oh! they are due to public stupidity in failing to accept our products, or all business is falling off. Is it? Or has somebody else made our product obsolete in performance, price, appearance, durability, or in many other ways? Let's be impartial—let's be cold-blooded about our products. In all but about two major lines the supply today exceeds the demand. You may love your product, but does the public? Don't ask your vice-presidents only, ask your employees, and the buying public, and if you have to scrap an item popular for many years, scrap it, or you'll have a finished-goods inventory and a rale at give-away prices.

Let's get our costs down. Let's discipline ourselves in advance—the ship trimmed for any blow; so when the blow comes we don't do expedient, hurried things through fright.

There's no question that prices have to come down and thus costs of production, distribution, all overhead, everything else. How do you do that? Easy comparatively. Get everybody into the act. Get together your design engineer, purchasing agent, production manager, sales manager, cost accountant, methods man, quality-control man, everybody who has to work on the design, production, and sales of your product. Start with the product in its package and make every piece and part stand on its own feet. Do you need the part at all? Can it be made of cheaper material without affecting its functioning or life? Can any part be redesigned to make it cheaper in the factory? Put everything in the business under the microscope—the people, the product, the organization, engineering, production, distribution.

Let's know our costs. Perhaps this should have come under the previous item, but I think it deserves a place of its own. Too many businesses fail because they don't know their costs or they are not known to all their people. I'll never forget the first time many years ago when I found that every dollar of direct shop labor was loaded with two dollars of overhead. I was startled and mad. I was trying to keep direct costs down. Who were these people who could spend two dollars for every one of mine? Furthermore, they didn't seem to be under any pressure to keep costs down. So, let's have an accounting system that is an up-to-the-minute tool and accurate. I know a big business in which the president holds a meeting every Monday afternoon with his executive staff, and they have a profit-and-loss statement for the previous week before them. I know it can't be done, but they do it. In most businesses you get the month's results the 25th of the following month, except at the close of the fiscal year when you wait three months for any month while they close the books.

Let's have budgetary control. And I mean at the only level where budgets can be controlled, at the foreman level and its equivalent. Let's have the foreman actually in on the preparation of the budget, before it's put into his startled and reluctant fingers as an accomplished fact. Make it his budget and he'll fight to meet it. And give him at least weekly and for a while daily results, so he'll know where he's going while the information is still fresh in his mind and he can do something about it promptly. Daily figures are desirable and even mandatory till you get straightened out. As part of budgetary control let's have a production and sales program for a year in advance at all times, adding a month at the end as each month is finished at the beginning of the year. Not for a fiscal year, not for a calendar year, but a schedule always a full twelve months ahead at any time. And let's have results charted showing where we plan to go and where we are really going.

Having a real team and having charted our course—let's sail the course into the sea of opportunity.

Let's modernize our plants. The war gave a great impetus to better machine tools and cutting tools. Yet many businesses are hanging onto obsolete worn-out machine tools. Never mind the fact that you haven't completely depreciated an obsolete machine tool on the company's books and that your cost accountant and treasurer shiver when you want to discard a tool before it's written off. Accounting must be the tool of business, not its master. Get the best possible tools as they become available and have a plant layout so that you handle your material and parts as few times as possible.

How about the layout of the plant? Have you ever made a flow chart of the movement of a component or raw material from the time it hits the receiving platform till it reaches the shipping dock in a complete unit? You'll probably find you almost wear the piece out before it gets into the finished product.

Let's have a research program. Some big companies do; many big companies don't, believe it or not. Most small companies don't. There should be a group in your company, dreamers if you will, thinking far ahead of current production and current design. It's fantastic how small is the percentage of the sales dollar devoted to research so the business will stay alive in years to come. Don't be afraid to let research people dream.

Let's tell industry's story. Whenever the union has a story to tell they tell it with pictures and the minimum amount of words—simple words that everyone can understand. When industry tells its story it has little white space, no pictures, and a mass of black ink, most of which are words that mean nothing to most people and convince fewer still. Industry has a great story to tell but let's tell it in language people can understand—the people whom we want to reach. We can't win new friends

by talking to the converted. The members of the Union League Club have a fine time convincing one another that they are right, but their influence isn't very widespread. Use pictures, exhibits, cartoons, and make it simple. And don't promise more than you can perform. Understate rather than exaggerate. People will then be pleased to find things much better than you have promised.

Let's be part of the world in which we live. Engineers have great technical minds and are responsible for the atom bomb, which may yet destroy the world, but when it comes to taking their place in Government and in civic enterprises, they are about as useful as a hitching post. The same leadership which displays itself so brilliantly in the laboratory or the shop is needed in running the affairs of the world. Engineers should take part in the Government, in the church, in the school, and might even try being human beings in their own homes. The world is sick and people are going to quacks. Engineers can't be quacks because bridges won't stay up and machinery won't keep on running with hot air and mere words, so let's be part of the cure. It's an industrial world, so industry must find the answer to peace as it found the answer to war. Believe it or not, many politicians, many churchmen, and many educators have already written off free enterprise. Not the free enterprise of money but the enterprise of free men of dignity allowed to go about their tasks with head held high in bondage to no group—business, labor, or Government.

And last, but far from least, let's keep human!

Let's put humanity into our human relations. The trouble today is worship at the shrine of bigness in business. What we have to do is break even our big corporations down to units of a size where the top man of the unit can know his people and get close to them. We simply must preserve the dignity and freedom of the individual. We want to be able to get as close to him as self-seeking groups. Don't let's hate our people because they belong to unions. Hate hasn't helped anything in the world yet. The only thing which can help is the opposite of hate, which is love.

Keep the people informed of every plan and of the results of their operations. Give them a profit-and-loss statement periodically. Find out what they are thinking and do something about it, and do it gracefully and promptly and not reluctantly after lengthy pressure. Don't be apparently or actually arbitrary in your rules. Tell people why rules are necessary and the why's of the rules and in language they can understand. Have flexibility enough in your rules to be human and yet have discipline. You don't have to be a "softie." People like success and want to be part of it and are willing to work under fair humane rules. They don't appreciate laxity and failure. They want to be part of a winning team.

A GAME WORTH THE EFFORT

In war we created the greatest winning team the world has ever seen. Perhaps it is because war is dynamic and exciting that we do such an outstanding job. All right, let's make business more exciting and more dynamic. Let's make it a game full of challenge, full of interest, full of excitement, with reasonable rewards for work well done. Let's give the people working for us who have the greatest investment of all—their lives—a good share of the profits they make. Let's get them into the game. Let's get into the game with them. Let them share in the victory and if we take advantage of their combined imaginations, energies, and talents there won't be many losses.

Let's learn from the past, but don't be bound by tradition as a strait jacket. Don't tell people when they make suggestions that "we tried that once and it didn't work." Maybe it will work now with minor changes; a little new twist or with somebody sparking the idea. It's the enthusiasm, it's the spirit, it's the team you build with spirit that can't be defeated that's going to win in this game.

We are in the greatest game of all—the game of life, and the opposition to human freedom, to free enterprise, and to the democratic way of life is formidable indeed. Don't let's ever underestimate our opponents, for suddenly a haymaker will come off the floor out of nowhere and flatten us with a thud. We can win if we realize the kind of a game we are in, the strength of the opposition, and how hard we have got to fight, but we can't win by being cocky, or by being rabbits and running the first time somebody makes faces at us. We can't win by sitting in the grandstand, we have to get down in the field and play the game. People today are desperate for leadership, and leadership that has a plan, seems to know what it is doing, talking the language people can understand—that's dynamic and that will give everybody a chance to contribute his or her share. Yes, they want to get into the game no matter how humble their part. As a matter of fact, they don't all want to be generals, but do want to have a humble significant part and have their part recognized. There is a tremendous untapped reservoir of power in the people and their common judgment is infallible.

No indeed, you can't fool all the people even some of the time. They have the number of the backslapper, handshaker, and baby kisser who doesn't mean it. They want honest treatment. They are looking for an honorable place in an honest game. They are looking for leadership that really leads, but it had better be honest leadership. As a union leader said one day at a meeting that outlined a program both management and labor could follow: "We will be glad to follow that program, but you had better mean it." So instead of criticizing or kibitzing, you had better have a constructive honest plan which you are willing to back with your money, your energies, and your life and—"you'd better mean it."

COMING INTO THE LAST ROUND

We are coming into the last round. The final decision is about to be rendered. We can win the game in this round, but we'd better give it all we have. There is no use trying to save our money, because money won't do us any good if the world collapses around our heads. The only thing that will help us now is character, integrity, and a real effort to satisfy the deep longings of people who are tired of broken promises, tired of unemployment, tired of empty meaningless words. But don't think they are too tired to drive out the incompetents, the self-seekers, the bunglers, no matter what their positions are. Kings of empires have fallen before this and kings of industrial empires can fall just as hard and just as fast. We'd better earn our kingship now and earn it every day. We can't rest on our past laurels; we can't promise action bye and bye; we'd better produce now not only the real hard goods, but the things of the spirit that our people want. It may take more imagination, more effort, more sleepless nights, more unselfishness, more love than we have ever shown yet, but it is the last round and we had better do it. There may be fewer cocktail parties, fewer golf matches, but the result can be a world of peace—industrial and international.

Every man who reads this message has to share in the program—wherever he lives, wherever he works. Yes, that's where to start. Start right where you are no matter how humble you think that contribution might be. It is the combined contributions of all that will bring that victory. There are no geniuses, no magicians, no magic wands. It is just you and I, but all the you's and I's added together means everybody. So if you and I within our little circles develop peace and understanding, thus and only thus will the world's problems be solved.

RESEARCH—OPPORTUNITY *and* CHALLENGE

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An interested inquirer undoubtedly would acquire the impression that research in industry has grown recently at a highly accelerated rate. I would confirm this impression. Stand research up against the wall, and apply to it whatever measuring sticks one will, its late increase in stature is impressive. Total expenditure? The current annual expenditure for research and development in the United States is estimated at a billion dollars—about three times the corresponding figure immediately preceding World War II. The Government has enlarged its share in the total expenditure from 20 per cent in 1940, to 50 per cent currently. In round figures, during this period, Government expenditures in research increased sevenfold, from \$70,000,000 to \$500,000,000. Industry's increase, while not so spectacular, is still formidable, from \$240,000,000 to \$500,000,000, or twofold (1).[1]

A second yardstick is the ratio of research expenditure to total sales. The National Industrial Conference Board drew the following carefully considered conclusion from a recent survey: "A majority of companies spend a larger proportion of their sales dollar on industrial research and development than in the immediate prewar years, notwithstanding the much higher level of sales." For valid reasons, no attempt was made to compute a composite figure. The median percentage was found to fall between $1^1/_2$ and 2 per cent, with costs in a few instances as high as 5 per cent (2).

A third significant criterion of growth is the number of persons engaged. The National Research Council furnishes the facts in the eighth edition of its directory, "Industrial Research Laboratories of the United States." The data were received during the period August, 1945, through January, 1946. Current figures, because of the completion of reconversion, would be higher. Not included in this compilation are college, university, municipal, state, and federal government laboratories, except for those of the National Bureau of Standards and the Regional Research Laboratories of the U. S. Department of Agriculture. According to this directory, total industrial-research-laboratory personnel has increased proportionally at about the same rate, for the same period, as has total industrial research expenditure, almost twofold. In 1940, total personnel was about 70,000; in 1946, about 134,000. Of the 1946 total, about 55,000 were scientific; 35,000, technical; and 45,000 administrative, clerical, maintenance, and similar personnel. The large majority of the 55,000 scientific personnel consisted of chemists and engineers, about 20,000 of each. The increase in chemists and engineers has been about equal since 1940, when about 15,000 of each were engaged (3).

WILL GROWTH CONTINUE?

A man seriously assaying research as a prospective lifework will next attempt to forecast its future, and, with this objective, analyze the foregoing factual and additional pertinent theoretical considerations. Has research recently increased at an accelerated rate? If so, what are the reasons for it, and will it continue?

Strict accuracy and complete inclusiveness are not, of course, claimed for research surveys, since the willingness of companies to answer questionnaires, and the variation in interpreting terms, and in bookkeeping practices, affect the results. However, surveys do show trends, and the trend indicated is an accelerated growth during the last six years, as compared with the preceding decade. Roughly, the average annual rate of growth in industrial-laboratory personnel over the 1930–1940 decade was 13 per cent; in the six years from 1940 to 1946, it was about 17 per cent. The expenditure for industrial research increased, during the earlier period, at an average annual rate of 10 per cent, while the same figure for the latter period was 17 per cent (1, 2).

What caused the accelerated growth? Undoubtedly, the extraordinary results of wartime research was one stimulus; another was the change in economic philosophy from a doctrine of scarcity in the last decade to one of plenty in this.

Another phase of current business philosophy tending to increase research is the thought being taken for the morrow of threatened recession from the present high industrial tempo. During the depression of the 1930's, a few hardy souls preached, practiced, and profited by the doctrine that the way out of the wilderness of depression was through the finding of new paths, the development of new products. In the 1930's, the doctrine was professed by but few, and those were looked upon askance; it is now firmly entrenched and advocated in the most respected circles.

Another reason for the rapid growth of industrial research is that it is a comparatively new member of the economic family. Of course, research itself is as old as civilization. Research as a segregated industrial activity, with individuality and responsibility of its own, is only about twenty-five years old.

The late Thomas Midgley, Jr., an outstanding figure in research, discoverer of the antiknock properties of tetraethyl lead, for more than twenty years vice-president of the Ethyl Corporation, and at the time of his death president and chairman of the American Chemical Society, discussed this point in the last paper presented before his death in 1944. Referring to the "sudden appearance of industrial research in our economy," he said, "Had industrial research developed simultaneously with modern industry over the past one hundred and fifty years instead of merely during the past twenty five (to a large extent), these fears (of the abuse of the power of research) would be nonexistent. That industrial research should have been developing over the one-hundred-and-fifty year period seems obvious to us now; its rapidity of growth during the past twenty-five years has been largely a 'catching up' process. Whether or not it has completely caught up with other industrial activities is a question for debate. I am of the opinion that it has not. Assuming that I am right in this opinion, there is still a further point for debate. Will it?" (4).

Address presented at the Annual Spring Conference of New England Student Branches of The American Society of Mechanical Engineers, Yale University, New Haven, Conn., May 9, 1947.

[1] Numbers in parentheses refer to the Bibliography at the end of paper.

That industrial research is still in swaddling clothes is indicated by the figures already quoted; a total cost of between $1^1/_2$ and 2 per cent of total sales; a total employment of only 55,000 scientists and 35,000 technicians. Compare this slight contingent with the millions in the industrial army. The chemical industry uses about one research worker for every thirty-five wage earners (1). Should that proportion be approximated even remotely for industry as a whole, the number of research workers would have to be increased enormously.

Some of the evidence for, and philosophy behind, the recent accelerated growth of research have been discussed. Will it continue to grow? Will it carry through the "catching-up" process? Three reasons for an affirmative answer may be advanced. The first, again in Dr. Midgley's words, is as follows: "Research has not yet come into its own with respect to many of the smaller units of industry. The larger units have been able, because of their position, to pioneer the general movement. This pioneer work was possibly too hazardous for the small units to undertake; but now that the exploratory stage is pretty well over and trained personnel is available for executive positions there is no longer any reason why the smaller units of industry should not make full use of industrial research for their own advancement and welfare" (4).

The National Research Council reveals the extent of industrial territory not yet penetrated by research. It estimates that one half of the 50,000 research scientists, technicians, and assistants, employed in industry in the United States in 1938, were working for 45 large companies. The other half were distributed among more than 1700 firms, so that more than 150,000 manufacturing concerns were without research laboratories (1).

Research for small industries was hailed recently by Edwin H. Land, president of the Polaroid Corporation, founder and inventor. Under his guidance, the enterprise developed from a small research laboratory in the early 1930's, to a sizable war-production industry. For his work in polarized light, he received the Hood, Cresson, and John Scott Medals, and the Modern Pioneer Award. He said: "I believe quite simply that the small company of the future will be as much a research organization as it is a manufacturing company, and that this new kind of company is the frontier for the next generation" (5).

Whether or not research will reach this predominant place in small industrial units is still to be seen; but admissibly the virgin field for research in small concerns affords it an opportunity for growth to occupy a more adequate portion of total industrial activity.

Another basis for the belief that industrial research would continue its rate of growth was emphasized by Dr. Midgley: "Our environmental universe is definitely expanding. Few discoveries of any importance are made that do not open up still greater fields for future investigation and, consequently, more knowledge to be used by industrial research" (4).

The rich fruits of scientific and technical knowledge brought forth under the hot sun of wartime urgency have still to be digested in the industrial system. The process of beating the swords into plowshares will require much development through industrial research. For example, one such adaptation of special interest is the use of radar to assist in the phenomenal accomplishment of discovering crude petroleum in the ground at a rate greater than that of current withdrawals. Many more similar types of adaptation are in the making and still to be made.

A third reason for belief in the continuing growth of research is the increasing appreciation by industrial organizations that research develops men as well as products. Research methods are being applied more and more commonly throughout management, and men trained in research are being continually transferred to positions of responsibility in other departments. Any activity that is effective in filling one of industry's most pressing needs, capable executives, will always be supported.

SHORTAGE OF RESEARCH PERSONNEL

The man considering research as a profession will next ask, granted that the demand for research workers is great: What is the relation of supply to demand? Properly qualified research personnel is admittedly short in supply; indeed, this lack is advanced by some firms as the limiting factor in research expansion.

For three years scientific training of undergraduates was practically at a standstill, and this, according to one published estimate, has created a deficit of science and technology students, who, but for the war, would have received bachelor's degrees, of about 150,000; the deficit of those holding advanced degrees, according to the same estimate, will amount to about 17,000 by 1955 (6). A thorough study of the supply and demand situation in engineering, made by the American Society for Engineering Education, leads to the conclusion that the deficit of engineering graduates to fill possible jobs was 25,500 in 1946, and will gradually decrease to 12,260 in 1951, changing to a slight surplus in 1952 (7).

The reservoir from which research workers must be drawn may be gaged by the membership enrollment of engineering societies. It seems fair to assume that this membership embraces the major portion of the active engineering profession. The combined membership of the seven societies covering the basic fields of engineering, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Chemical Society, The American Society of Mechanical Engineers, The American Institute of Electrical Engineers, the Institute of Ceramic Engineers, and the American Institute of Chemical Engineers, is about 131,000 (8). From this pool must be drawn not only research workers, but all engineering personnel from detail designer to top executive.

RESEARCH—THE CHALLENGE

So far, the rosy side of the research prospect has been presented. Industrial research is in a period of accelerated growth; both statistics and economic theory support this conclusion. A continuing expansion is justified by the virgin fields and the wealth of scientific material awaiting industrial research and development. The supply of qualified personnel is far short of the demand. Is there a less enticing aspect of the situation; are there dark spots in the glittering vista of billion-dollar expenditures, million-dollar laboratories, shiny, new equipment, and fourth-dimensional research theory?

The engineer knows that every action has an equal and opposite reaction. The equal and opposite reaction to opportunity is responsibility. Industrial research faces a serious challenge. Every dollar added to its appropriation intensifies that challenge. No longer a stepchild of the sales or production department, research must assume its place as an independent member of the industrial family and make its proportional contribution to the family income. Research must produce results, and to industry results mean simply increased profits. The profit motif was well expounded by R. S. Tucker, economist, General Motors Corporation, in discussing another aspect of industry, "wages and productivity." He said, "The profit motive has been the device by which philosophical and academic speculations have been compelled to serve the wants of the common man" (9).

RESPONSIBILITY OF RESEARCH MANAGEMENT

Research management and research workers down to the humblest laboratory assistant share the responsibility for mak-

ing research pay. Research managers are keenly alert to the seriousness of the challenge. They know that large laboratories and expensive up-to-date equipment do not produce research results automatically. As a recent speculator on the status of the attic genius wrote: "The Goliaths may hold a monopoly on the large capital and equipment, but they have not a monopoly on the brains and never have had. Printing men did not invent the linotype. Oil companies did not invent the electric light. Telegraph companies did not invent the telephone. Railroads did not invent the air brake. Mr. Frank B. Jewett (vice-president of the American Telephone and Telegraph Company in charge of development and research, 1925–1944) is authority for the statement that of the three big telephone improvements, two of them came from outside the Bell Laboratories (10).

The author has pointed a discerning finger to the keystone of success in research—personnel. The research manager's hardest job in making research pay is to select the personnel and so organize it as to stimulate it to its best efforts.

Does the atmosphere of large-scale research offer any advantage over the lone-wolf procedure in achieving significant results? The case for the affirmative is put by Frank A. Howard, former president of the Standard Oil Development Company, organizer of the research unit of the parent company, and its administrative head from its inception in 1919 to 1945. He says: "The record shows that in an environment of organized research and development effort, the inventive mind reaches a level of productiveness beyond all past experience (11)."

Providing this "environment of organized research" constitutes the research manager's heavy burden of responsibility. In a large laboratory, he must guard against breaking down projects into too minute and simple portions, as in a production assembly line. In such overspecialization, a promising creative research worker might be whittled down to a routine laboratory tester. As manager, he must exert the necessary control and direction, without impeding the freedom of thought requisite for research. The problems of sales and production must be considered, but the viewpoint of research maintained. The research manager must guard himself, and, more important, the company officials to whom he is responsible, from the fallacy that money spent necessarily means results obtained.

Too many people diagnose the success of our war research as due to large appropriations. The real reason undoubtedly was the urgency of the national need. Our technical men knew full well the extent of our unpreparedness, and the danger that we might lose the war. Under this impetus, they extracted from their brains and bodies the last ounce of scientific knowledge, technical skill, and ingenuity. The first and last great responsibility of the research director is to provide in his organization the inspiration and co-operative spirit that shall be a reasonable peacetime facsimile of this wartime impetus.

RESPONSIBILITY OF RESEARCH WORKER

Any worker is always the more effective for a sympathetic understanding of his boss's problems. However, his primary concern must be his own responsibility for the success of the undertaking of which he is a part, and this involves his own personal success. My earnest recommendation to the prospective research worker is that, as his first step in assuming this responsibility, he inventory his own personality. Is it adequate for and congenial to research work? This recommended inventory does not refer to educational equipment nor to the type of mental trait assayed by the so-called aptitude or intelligence tests. Such tests are not concerned with character, and if improperly interpreted and evaluated tend to detract from the emphasis which should be placed upon this most important component of a student, or of any man.

The importance of personality in successful performance of a job has been pointed up recently by the application of a personality-measuring machine in industry. The use of this device is based upon the axion that you cannot hire skill and aptitudes by themselves—you must hire the whole man. The method was developed in a university department of anthropology as one outcome of nine years of pure research. It has been used for two years on personnel and organization problems in New England. This experience is said to "demonstrate that the personality factors in the definition and performance of a job are fully as important as the functional description of the job," and to support the conclusion that the basic cause of industrial unrest is that people are unhappy in their jobs because they are miscast for them (12). A different name was given to this element of character by F. V. Geier, president of the Cincinnati Milling Machine Company, in a talk to the American Society for Engineering Education. "Attitude," he said, "is important because you can't get things done without it. . . . in our own training school, which starts with college and engineering-school graduates, but mostly with high-school graduates, we have finally come to put attitude at the top of the list, because it seems to be the thing that is most helpful to the man's future progress with himself and with others.

"Curiously enough, after we had been emphasizing attitude with these younger men in training over a period of time, there was a greater demand among our executives for these boys who came out of that training school than there was even for the boys with university and other types of higher education; that these boys, with basically less educational, intellectual, and background advantages, were nevertheless easier to work with, more adaptable, and ready to go ahead and do things" (13).

The Engineers' Council for Professional Development recently made a survey to determine from a representative group of industrial employers their attitudes and policies pertaining to the selection, training, placement, advancement, guidance, and professional activities of engineering-graduate employees. The report states: "The questionnaire listed nine items presumably considered when selecting an engineering employee, asking each co-operator to list the order of importance given to each in arriving at an over-all evaluation. From a statistical analysis of the replies, weighting the first, second, and lower choices in the way that preferential ballots are usually counted, the considerations which carry the most weight in selecting a candidate for an engineering position, in the order of their importance, are as follows:

1 Personality.
2-3 Scholastic record.
Indicated promise of development in specific field of engineering.
4 Engineering experience.
5 Evidence of ability to co-operate with others.
6 Recommendations by qualified persons.
7 Indicated promise of executive development.
8 Standing of college from which candidate was graduated.
9 Salary requested.

"If only first choices are considered, the order of preference is somewhat changed, engineering experience ranking second instead of fourth, but personality still leads the list" (14).

PERSONALITY OF RESEARCH WORKER

What personality traits should a research worker have? T. A. Boyd, now for many years associated with the Research Division of the General Motors Corporation, devotes one fifth of his book, "Research, the Pathfinder of Science and Industry," to a discussion of the qualifications of a research man. His list of a dozen qualifications includes no mention of those endow-

ments commonly regarded as intellectual, nor any item of training, but only those attributes commonly associated with the words "character" or "personality." His list is as follows:

Youth—not only in years but in the state of mind.

Curiosity—not about what the neighbors are doing, but about what things can be expected to do.

Imagination—the ability to theorize, to formulate the opinions or the speculations of an investigator into a theory, which serves to stimulate and direct further investigation.

Experimentalism—the urge to try it out and see.

Enthusiasm—wisely and intelligently directed.

Patience—because research consists largely of an educational process, education of the research worker himself, and education is always slow.

Persistence—a research worker must be not only a good starter, but that much rarer type, a good finisher.

Faith—faith in the ultimate outcome of necessary investigations; the refusal to believe that a thing is impossible simply because at the time you do not know how to accomplish it.

Courage—of action and of belief.

Common sense—to guide decisions on what investigations to conduct and how.

Honesty—not only as a policy, but as a universal creed.

Modesty—the ability to take your work seriously, but not yourself (15).

Compare this list of qualifications, drawn up by a research man in industry, with a similar inventory by an educator interested in research. Dr. A. A. Potter, dean of engineering, Purdue University, in a truly classical monograph on "Engineering Research as a Career," wrote:

"Great research men possess a spirit of adventure, imagination, ingenuity, clear vision, persistence, absolute integrity of purpose, good training, and a spirit of unselfish service for the benefit of humanity. A person to be most successful as a research engineer must be interested in creating new things, in discovering new laws, in perfecting new processes, in solving new problems, and in extending the boundaries of human knowledge. Co-operative ability is very valuable for a research man. No person should take up research as a career if his aim in life is to make money. Good research men are well paid but they find their greatest reward in their love of the work. Their inspiration comes not from monetary returns, but from a desire for achievement" (16).

IMPORTANCE OF IMAGINATION

Of the qualities enumerated, the one I wish to emphasize is customarily associated with artists, poets, real-estate promoters, stock salesmen, and liars generally—imagination.

H. R. Ricardo, the well-known English engineer, recently discussed the importance of this quality as part of the research man's mental equipment. He said: "The fundamental research worker, to be successful must have not only a thorough knowledge of his subject, but he must be endowed both with imagination and unlimited patience. . . . To be successful the applied research worker must also have a vivid imagination" (17).

What is imagination? Shakespeare and other poets have literary and florid descriptions. The psychologist's briefer, less fanciful, but no less valid definition is that imagination is the consciousness of objects not present to sense. It is, further, the ability to combine old elements in a new way to make a new whole. It is the envisioning of a subject through the lens of one's own mind and personality, instead of through that of textbooks and formulas. It is the faculty of conceiving a thing as a whole through the unconscious cerebration of fancy, instead of building it up according to the rules of thought that have been formulated in the name of reason. Again, quoting the psychologists, it is "the method whereby we shake off the shackles of the world of objects immediately present to sense, and secure the freedom to overstep the limits of space and time as our fancy, or our necessity, may dictate." Its characteristics are individuality and constructiveness.

It will be noted that imagination is not credited with being creative. Man does not create; the elements of everything on the earth now were put there in the first six days. The Bible says that the Creator rested on the seventh day, and so far as scientific evidence goes He has been resting ever since. But to realize the possibilities of those elements and to apply them to the satisfaction of human needs required the imaginations of our mental pioneers—inventors and discoverers.

Imagination, unaided, has produced inventions of surpassing importance. Two devices, designed by primitive man, which are the bases of many of our present-day machines, may be cited. The savage knew nothing of the science of ballistics, yet he made the bow and arrow, and incorporated in it all the elements of missile weapons since developed—a projectile, a means of hurling it, and the power for operating the means. A happier example of the service rendered human progress by the imagination is the wheel. Almost as far back as our knowledge goes, man has used wheels. The savage who first noticed that he could roll a log over the ground more easily than he could slide it knew nothing about the laws of friction; he had an idea and the wheel was its embodiment. Where would we be today without wheels; no gears, no rotary mechanism, no locomotives, no automobiles?

Can imagination be developed? As in the case of every other quality, physical or mental, a person is limited by his natural endowments, but within these limitations the possibilities for development are far beyond those ordinarily achieved. Imagination, like an organism, grows by food and exercise. The food of imagination is perception. The mind must be stored with impressions seen and assimilated by the individual, not absorbed through textbooks. For true richness of imagination, impressions should not be restricted to the field of immediate utility. The mind should be kept open to the stirring messages of truth as expressed in the media of line and color word and sound. In the exercise of imagination, solitude and individuality are essential. A man must explore the resources of his mind, free his thought from convention and the fear of nonconformance.

The imagination must be disciplined as part of its cultivation. "He who has imagination without learning has wings but no feet," says a French writer. Our fancies must be subjected to the reins of reality; our ideas verified from the storehouse of knowledge available to us. An undisciplined imagination makes a Jules Verne; a disciplined imagination, a Leonardo da Vinci, Goethe, or a Steinmetz.

Some caution must be used in applying imagination. The imagination must not be relied upon to ascertain definitely measurable facts. One must render unto the micrometer the things that are of the micrometer and to imagination the things that are of the imagination. But scrutinize closely all claims to factual absoluteness and view with suspicion formulas and systems which claim to establish truth through the exercise of pure reason. How frequently do we encounter in scientific journals a treatise claiming to settle for all time this or that controversial subject. Taking for his unwitting accomplice that most exact of all sciences, mathematics, the author reduces the entire matter to formulas, of which often the very keystone is something called a "coefficient" of this or that, a quality or quantity for which there is no exact measurement and which is a purely empirical determination.

For many years I have had framed on my office wall C. F.

Kettering's little fable about the bumblebee. It reads: "According to theory of aerodynamics and as may be readily demonstrated through laboratory tests and wind-tunnel experiments, the bumblebee is unable to fly. This is because the size, weight, and shape of his body, in relation to the total wing spread, makes flying impossible.

"But the bumblebee, being ignorant of these profound scientific truths, goes ahead and flies anyway—and manages to make a little honey every day!"

The research worker who has learning without imagination is like a fellow "all dressed up with no place to go." While design is dealing with known elements, research is concerned with the exploration of the unknown, a task in which imagination is the only incentive and the only guide. That the imagined goal is frequently not attained is unimportant. The important thing is that imagination has lead the research worker into realms of unknown fact or theory; while there he is certain to discover something new. At any rate, he certainly would never have discovered anything if he had not started.

Man in his search has discovered much about the elements of the world which surround us, and has gone far in his analysis of their nature. But I believe that the young men of this generation, who at the very outset of their careers have had to undergo the discipline of a war era and the difficulties of a reconversion period, should be especially well qualified to make progress in advancing the outposts of human knowledge.

EDUCATION FOR RESEARCH

After the prospective research worker has satisfied himself that he has the appropriate personal qualifications, what basic educational preparation should he make? My only advice, and it is emphatic, is to concentrate on fundamentals, and to avoid specialization in any one narrow field of engineering. The need for thorough grounding in fundamentals is stressed in the survey of the demands for and supply of engineering graduates previously referred to. It states: "This sharp increase in emphasis on research and development . . . may well point to the increasing need for the extension of more basic science in undergraduate engineering curricula. . . these points have been emphasized in recent years by engineering educators who have watched the trend away from 'handbook engineering' and toward the application of more fundamental science to modern engineering problems" (7).

The body of scientific knowledge is so great that to acquire a mastery of only its rudiments is a task worthy of all one's efforts. Specialization in any one field of engineering has one of two objectives, namely, (*a*) manual dexterity or practical ability; and (*b*) specialized theoretical knowledge. Practical applications of engineering knowledge are taught in the technical institute and in factory apprentice courses. Of the former, this country has far too few; of the latter, industry presents many notable examples. Specialized scholastic knowledge should be pursued in the graduate school.

If, in college, the student gives adequate attention to securing the necessary groundwork in fundamentals, he will not have time to gain sufficient skill in any one branch to be of practical value to him. Specialized jobs in industry are not routine monkey tricks that can be learned in a course of three hours a week for six months or a year. They are concrete opportunities for expressions of fundamental principles, that call for thorough understanding of these principles, and sometimes years of training eight hours a day, every day. Each specialized job in industry, too, is influenced by practical considerations, peculiar to the individual problem or the individual firm, which cannot be reproduced in college courses. The man with a smattering of vocational training may have a slight advantage in gaining an initial toe hold, but he loses out in the long run to the student who has utilized all his time in learning the fundamentals—itself a stupendous four-years' task.

Dean Potter, in the monograph previously quoted says: "Engineering research is based upon physics, chemistry, and mathematics. The more thorough the preparation in these subjects the greater are the chances for success. The greatest contributions to engineering progress can best be made by a person who has not only engineering knowledge, but also a broad and thorough training in the sciences which are basic to engineering" (16).

That employers of engineers place a high value upon the knowledge of fundamentals is indicated in the Engineers' Council survey previously cited. Of those questioned, only 14 per cent voted "no" on the question, "Is the present college training of engineers satisfactory?" In the list of six predominating criticisms, lack of the fundamentals, physical sciences and mathematics, was placed first (14).

CONCLUSION

For those who are contemplating research as a field of endeavor, I have tried to indicate its opportunities, its drawbacks, the required personal qualifications and educational equipment.

At the moment, no discussion of opportunity in American industry would be complete without reference to the new book (18), "Land of Plenty," by Walter D. Teague, one of the country's leading industrial designers, and any adequate treatment of the subject as related to engineers cannot fail to include items of his picture of America's abundant future. Therefore, with credit to Mr. Teague, in closing, I wish to discuss a broader topic, namely, choice of the basic objectives of an engineering career. I am emboldened to step outside my assigned subject for two reasons: The choice between the two specified objectives will determine every decision in one's professional life; I am convinced by my own observation and by the advice of men who are in close contact with engineering students that too many of them are making the wrong choice.

The choice lies between security and opportunity—one cannot have both; and an unfortunate trend toward security as the ultimate objective is making itself felt among engineering students both in college and in the ranks of industry into which they are entering.

The longing for security is a deep-seated, atavistic human trait, originating in man's reaction when he first became conscious of his environment, and found it fearsome. When whole nations are moved to worship this fetish of security, the totalitarian state results; but, in the case of nations, the fear is directed not toward environment, as in primitive man, but toward men of other races or other philosophies of life.

In such states, the individual dwarfs himself to the dead level of the mob, so that he may submerge himself in it and there find security. He trades freedom of thought for mass psychology, and freedom of action for regimentation.

Abortive attempts have been made to bind the energies of this nation in the strait jacket of security. Back in 1886, Carroll D. Wright, then Commissioner of Labor, studied the world situation and collected an impressive array of economic and industrial statistics to support his conclusion that our economy had reached its final stage, that no further advance was possible, and that our efforts should be devoted toward conserving what we had. Fortunately, no one at that time paid much attention to his report, and the country entered on a forty-year period which brought forth electric utilities, the whole power industry, the internal-combustion engine with its satellites, the airplane and the automobile, the oil industry, movies, the radio, electronics, plastics, the construction of vast nation-wide highway networks, huge new cities, and notable advances in

chemistry, medicine, household comforts, and the standard of living in general.

In the early 1930's, Wright's "mature economy" doctrine was resurrected, and we were officially told that we had "gone about as far as we could go." No more public lands were available, our industrial plant was built, we could make more shoes, textiles, steel, radios, and automobiles, in fact more of everything, than we could use. The frontiers of development were closed, we should sit tight between our two oceans, and play it safe, venture no more, but guard the status quo. Under this stultifying doctrine, production during the 1930–1940 decade fell below the level existing in 1929. Depression ruled the decade, and in 1940, 8,000,000 potential workers were still unemployed.

Then the bombs at Pearl Harbor blew the mirage of security into smithereens. The country was shocked into the realization that in the swiftly moving currents of life no such course as just standing still is possible. We as a nation must either be swept downstream with the flotsam of the impotent, or battle upstream to find our place in the world order. War needs inspired the "expanding" economy; and the same managements, technologists, and workers whose capabilities had been sunk in the enforced lethargy of the "mature" economy doctrine seized upon the opportunity offered by this new order. The enormous increase in productiveness and technologic advance is history. By mid-1946, the goal of 60,000,000 jobs, thought by the "mature" economy doctrinaires to be obtainable only through various "pump-priming" devices was reached through the natural expansion of industry. Twelve million more people were employed in civilian production in July, 1946, than in 1940, and at much higher wages.

For the individual, as for a nation, a philosophy motivated by security as opposed to opportunity is at best unsatisfactory, and at worst, dangerous. It is a vestigial mental attitude, inspired by fear; and fear, if negative in its reaction, leads to the restriction of capabilities, frustration, and dissatisfaction, and, if positive, to injudicious or frantic activity. The search for opportunity, the desire of man to become the captain of his fate, the willingness to make decisions and to abide by them—all these constitute a fairly recent pattern of behavior in the history of mankind. Only with this dynamic philosophy may a man realize his capabilities to the utmost, and in this fulfillment find ultimate happiness. Wealth and progress come to a civilization from the unpredicted and unplanned contributions of countless individuals. Such contributions are the result of constructive thought, which is the peculiar property of the individual and not of a regimented human mass. And the individual can assume his full stature only when he is walking toward the light of opportunity, and not crouching in the somber shelter of security.

Regard your profession not as a means for keeping a roof over your head, and bread on your table, but as an opportunity for exerting your full capabilities, and serving mankind through advancing your profession. When you are considering a job, ask, not: "Does it guarantee security, will the company take care of me, good times and bad?" but rather "Does it offer opportunity?" Don't gamble recklessly, but in weighing your decisions assign a high value to opportunity, and place it on the side of the balance that indicates an affirmative decision. Only with such a philosophy, dynamic, favorable to freedom and growth, can you achieve the best for yourself and for your profession, which has been called "The science that holds in its hands the life and death of the world."

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Apprenticeable Occupations

IN answer to the increasing number of requests for information on the occupations in which apprentice training is given, this subject has been covered in detail in a new and enlarged edition of the "National Apprenticeship Program" recently published by Apprentice-Training Service, U. S. Department of Labor.

In addition to an explanation of the operation and development of apprenticeship in American industry, the 1947 edition of this pamphlet contains a list of 110 basic trade classifications in which apprenticeship programs are established, the various occupations under each classification with the time required for training, as well as criteria and procedures for determining the apprenticeability of an occupation.

This information is of special value to training directors, company officials, labor representatives, members of apprenticeship committees, vocational authorities, and others concerned with training men for craftsmanship in the skilled trades.

How apprenticeship programs are established and conducted today, and the functions of Apprentice-Training Service, state apprenticeship agencies, national, state, and local apprenticeship committees are also explained.

Copies of this informative pamphlet can be obtained free of charge by communicating with Apprentice-Training Service, U. S. Department of Labor, Washington 25, D. C.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

COMPILED AND EDITED BY J. J. JAKLITSCH, JR.

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context, and credit to original sources is given.

Foreign Industrial Workers

AN article in the July, 1947, issue of *Factory* tells how industrial workers around the world are living today. On-the-job and in-the-home interviews were conducted with automatic-screw-machine operators in America and 13 foreign countries. Automatic-screw-machine operators were chosen for the survey because they are representative of production workers and have comparable jobs the world around. The story describes and illustrates in detail working and living conditions, and compares hours and wages, itemized costs of living, foods available, taxes, and recreation, proving that our American economic system gives workers so much more than any other country can offer.

According to *Factory*, the industrial worker all over the world, in all but a few countries, finds life difficult today—two years after the close of World War II.

He is worn down by the daily burden of finding food and shelter. In at least four of the great nations covered in this world-wide survey the worker has practically no margin between himself and hunger.

Only in the United States, Canada, South Africa, and Sweden do the workers interviewed have even the smallest of the comforts they want in life.

At the other extreme is the Indian worker who can only guess at what life will bring him.

Between the extremes are nine countries, France, Great Britain, Germany, Italy, the Netherlands, Argentina, Mexico, China, and Australia, in all of which the workers fare poorly—some much worse than others.

The American worker, representing the nation with the world's highest production per worker, enjoys more of the comforts, leisure, and luxury of living than any other worker.

To give some idea of conditions abroad, Table 1 summarizes the incomes and living expenses of each of the workers interviewed in the 14 countries surveyed.

In Germany employment cannot insure enough to eat. Few Germans would have difficulty paying for their legal rations, but even the meager ration of 1550 calories per day for a normal adult is not being met in most industrial areas of western Germany.

In the industrial areas, nine chances out of ten, his home is either damaged or destroyed. If damaged, repairs, if any, are crude. If destroyed, he and his family may be living in the cellar, in a patched-up room in a bombed-out dwelling, in an air-raid bunker, in a shanty, or with another family.

The search for food occupies a large part of the time. People start lining up for bread at one o'clock in the morning.

To get extra rations, the average worker must exchange personal belongings, or spend savings, or illegal profits.

The devastation of war of course has reduced living standards in many countries. Moreover, the United States, although it devoted its major industrial effort to the production of the materials of war, was not bombed as Germany and England were. So it is obvious that the American worker will have more than the workers in most other parts of the world.

But even before the war the American was far better off than other workers. For example, in 1940 the American worker could buy 7.5 lb of bread with an hour's work. The British worker could buy 5.2, the German 2.5, and the Russian only 1.9 lb.

A French worker had to exchange 7295 hr of work for a standard moderately priced car. In Germany the worker could earn a similar car with 5054 hr of work. The English worker earned his car in 3522 hr. But the American needed to put in only 853 hr.

The war widened the gap between the American and his

TABLE 1 WORKERS' INCOME AND OUTGO IN 14 COUNTRIES

	United States	France	Great Britain	Germany	Italy	The Netherlands	Sweden	Argentina	Canada	Mexico	China	India	Australia	South Africa
Straight-time hourly rate (dollars)	1.45	0.42	0.94	Figures here would mean little because of extreme shortages in Germany today	0.15	0.48	0.79	0.38	0.82	0.30	0.09	0.11	0.41	0.45
Hours worked each week including average overtime	40	45	44		55	48	48	45	48	48	75	48	49	49
Average weekly income including overtime, bonuses, and cost-of-living allowances (dollars)	73.00	18.90	44.00		8.61	23.04	37.80	17.50	39.36	14.00	13.84	8.28	24.00	30.55
Weekly food costs for family (dollars)	28.50	17.65	12.00		9.85	14.44	16.80	8.75	18.00	10.00	6.25[c]	4.20	29.34[d]	17.10
Weekly cost of shelter (dollars)	10.40[a]	0.32	4.00		....[a]	2.23	4.48[a]	2.00	4.65	....[a]	0.46	0.56	5.15[d]	10.84[a]
Direct taxes paid weekly (dollars)	4.11	3.02	13.10		1.03	1.50	4.54	None	0.77	0.14	None	None	3.80	None
Balance (dollars)	29.99	6.30	26.90		0.61	6.15	11.98	6.75	19.94	8.36	7.13	3.52	15.30	15.06
No. of times they eat meat each week—not including factory lunches	10–12	2	2		2–4	1	4–6	14	8–12	1–4	1	1	7–14	4
No. of rooms they have	6	3	4		4	4	3	3[b]	5	3	1	1	5	5

[a] These families own their homes; figures shown include interest, amortization, and taxes.
[b] Shared with another family.
[c] Computed before recent sharp rise in price of rice.
[d] Lives with parents; contributes $4.90 a week to family budget of $29.34 for food and fuel, plus $5.15 for rent.

counterpart abroad. And it did something else. It underlined for all people everywhere the lesson that the American system of high output and low costs, of steadily increasing output per man per hour to make more goods for more people at less cost, is the way toward a higher standard of living.

Managements of many companies may find in this article some useful economic facts which they will want to pass along to their employees. To make this possible, *Factory* is prepared to furnish reprints of the article in quantities at a slight charge.

Synthetic Proteins

THE first synthesis of substances with general molecular structural characteristics identical with those of fibrous proteins, the fundamental units of which all forms of animal life are constructed, has been announced by Dr. Robert B. Woodward, associate professor of chemistry, Harvard University.

The synthesis has important possibilities in many areas of biology, medicine, and plastics science and technology, because it introduces an entirely new class of synthetic materials from which useful fibers and transparent films can be made. It is the closest man-made substance to nature-made proteins and therefore is reported to be the first significant opening wedge into the study of the synthesis of proteins within the body; it may lead to the synthesis of antibiotics. The simplicity of the process permits scientists to study more readily than ever before some aspects of polymerization, a chemical process of attaching large numbers of atoms together.

Starting with small molecules, Dr. Woodward succeeded in forming long protein-like molecules comparable to those found in hair, muscle, nerves, skin, and other forms of living matter. Thus the new process opens the way to the large-scale production of protein-like substances almost identical to some of the substances which make up the cells of the human body.

The process is a "self-propagating reaction" which hitches carbon and nitrogen atoms end to end to form molecules having the same general structural characteristics as those of natural proteins. At the starting point of the process are alpha amino acids which can be obtained readily from natural products like meat or vegetables, or by synthesis from coal, air, and water.

Amino-acid chains consisting of ten thousand units have already been made by the new process. The length of the amino-acid chains of natural proteins varies between one hundred and tens of thousands of units.

The new synthetic molecules are at least as long and probably longer than any ever made and there is a good possibility that the process can be used to produce molecules even longer than any that exist in nature today. This means that the new class of molecules, capable of being produced in thin transparent sheets and in thread form, opens up an entirely new field of plastics potentially as useful as each of the broad classes of plastics which have been put to such great practical use in recent years. The present classes include cellulosics, nylons, silicones, vinyls, phenolics, alkyds, and bunas.

Synthetic silk-like threads have already been produced by ejecting solutions of synthetic protein analogs from a hypodermic needle into warm air. This thread is of particular interest in textile manufacture because it is the first man-made thread which has a molecular structure very similar to that of the natural protein, silk. In this respect the new plastic products differ from the nylons.

A thin transparent plastic film has been made from the new materials by pouring solutions of protein analogs on a flat surface. After the solvent has evaporated a few minutes later, the film may be stripped from the flat surface. The experimental films produced to date vary in thickness between 0.00005 and 0.0008 in.

The new synthesis is especially significant in medicine because it may provide a model for the processes by which the body synthesizes proteins.

For the first time, without the aid of internal human machinery, it is reported to be possible to convert alpha amino acids into protein-like molecular arrangements comparable to the molecular arrangements of the substances that make up human beings. This may lead to the manufacture of synthetic silk, wool, and fur. These possible synthetic materials will be almost identical in every respect to the animal-made products, not just substitutes which resemble them.

Another important aspect of the new process is that it opens the way to the production of molecules heavier than those of virus proteins, until now the heaviest of all molecules. Also, it enables scientists to lengthen the molecular chains already present in natural proteins. This may lead to a method of modifying virus proteins into harmless organic substances, and it may make it possible to block the growth of harmful pathogenic bacteria, or change them into harmless forms.

It may also be possible to make germ-killing substances produced by various bacteria, particularly soil bacteria, since they have molecular structures much like those of proteins although their molecules are much smaller.

Gas Analysis

ACCORDING to Technical Report 1102 of the National Bureau of Standards, the mass spectrometer, one of the newer analytical instruments, has shown itself to be a remarkably useful apparatus in the analysis of gases and complex mixtures of gases. Many industries, such as gas, petroleum, chemicals, and rubber, rely heavily on gas analysis, and any improvement in methods or apparatus is of far-reaching importance. The mass spectrometer is said to offer an entirely new and different instrument for this type of analysis. It can in one operation resolve a very complex mixture of gases in a few moments of instrument time, although subsequent computing may require hours or even days, depending upon the complexity of the mixture and the method of computation employed.

The nearest approach to a real qualitative and quantitative system of gas analysis that has yet been devised is offered by the mass spectrometer.

It separates various gases on the basis of the actual weight of the ions characteristically produced on dissociating each molecular species by electron bombardment. In many instances such a separation affords a clear-cut identification of each component of the mixture. Usually the quantitative resolution of the mixture may be achieved by the proper mathematical treatment of the spectrometer data; and often the qualitative and quantitative processes are simultaneously conducted as in the case of the older chemical methods.

Both the mass spectrometer and the conventional volumetric chemical methods have recently been used by a group of co-operating laboratories in the analysis of a standard sample of natural gas. Twenty laboratories possessing a total of 21 spectrometers participated in the spectrometric tests, and 30 laboratories in the chemical tests. This represents one phase of study of existing methods of gas analysis by means of a nation-wide co-operative analysis of standard samples, which the National Bureau of Standards is making in co-operation with a subcommittee of the American Society for Testing Materials. (These samples are not to be confused with the regular standard samples issued by the Bureau for purchase, but are carefully pre-

pared gas samples furnished to co-operating laboratories). Reports of this co-operative analysis give for the first time a picture of the actual state of gas analysis in this country with respect to 2 of the 3 most important methods of analysis, the third method being fractional distillation.

All analytical data, together with the average values derived from each series of analyses, have been translated from extensive tabular form to a set of frequency-distribution plots which reveal at a glance the entire story both in general and in essential detail.

In general, the results are scattered considerably more than had been expected. The lack of reproducibility between laboratories clearly demonstrates for the first time the real need for standardization of analytical methods and procedure in the field of gas analysis. Although the spectrometric values show better reproductivity and closer agreement with the known composition than do the chemical values, further improvement is believed possible. As the method is new and has not yet been subjected to great variations of apparatus and procedure, efforts are being made to establish a standard procedure that will lead to even better results with the mass spectrometer.

British Jet Engine

A DESCRIPTION of the "Ghost" gas-turbine airplane engine, developed by the de Havilland Engine Company, Limited, Stonegrove, Edgeware, Middlesex, England, appears in *Engineering*, June 20, 1947. The Ghost which follows the de Havilland "Goblin" jet engine, is a much more powerful model. Although the Ghost is only 53 in. in diameter, as compared with 50 in. for the Goblin, it develops a static thrust of 5000 lb, compared with the current rating of 3000 lb for the latter. At 600 mph at sea level, the power output of the Ghost corresponds to 12,000 hp from a propeller-driving engine, assuming a propeller efficiency of 66 per cent. It is expected that, with tuning-up and later development, this figure will be exceeded.

In basic design, the Ghost is similar to the Goblin and embodies a high-velocity ducted intake feeding a single-sided impeller, a straight-through combustion system, and a single-stage axial turbine with direct ejection. The arrangement is claimed to give the shortest, simplest, stiffest engine obtainable within a given cowl diameter. The importance of a compact engine with a minimum divergence of gas flow is indicated by the fact that 140 tons of air per hr are compresssd, heated, expanded, and ejected at a nozzle velocity of more than 1000 mph. The consumption of air is about 26 times that of a 2000-hp piston engine, and about 9000 hp is developed in the turbine shaft in compressing this quantity of inhaled air. The advantages of the adoption of a single-sided impeller result in a simple rigid rotating component and provide for direct rearward flow of the gases. The impeller and turbine wheel are mounted on a tubular main shaft, and the opposing thrusts of these two elements largely balance each other, leaving only a small residual thrust to be taken by a single bearing. The tubular shaft is in tension.

The engine is built up of five main assemblies: namely, the compressor with the rotating shaft and center casing; the combustion system; the turbine; the exhaust-cone assembly; and the wheel cases. The compressor casing is built up of a front aluminum-alloy casting in which the air intake is formed, and a magnesium-alloy diffuser casting, which is formed in two parts divided vertically. This assembly is bolted to a cone-shaped center casing, which is a steel member forming the main backbone of the engine. The small end of the cone is bolted to the rear bearing housing just in front of the turbine wheel. The impeller is made from a heat-treated aluminum-alloy forging. It turns the impinging air stream through 90 deg, and discharges it radially into passages cast in the diffuser casing. The rear side of the impeller is formed with a series of concentrically arranged labyrinth grooves which mate with corresponding grooves in a sealing plate bolted to the diffuser casing, the arrangement preventing air leakage from the tips of the impeller blades, down the rear face of the impeller and into the conical center casing. The discharge passages in the diffuser casing are fitted with cascade blades, in which the velocity of the air is decreased and its pressure increased before it is discharged into the combustion system.

The combustion arrangement consists of ten combustion chambers and their ten atomizer-type burners, which are supplied with fuel from the burner manifold. There are twin entries to each combustion chamber connecting to the diffuser passages. The upstream ends of the combustion chambers are bolted onto the rear face of the diffuser and their downstream ends are fitted with piston rings and form a sliding fit with the turbine nozzle box, so that they do not constitute structural members. Each combustion chamber tapers toward its downstream end. Each is composed of an inner flame tube of heat-resisting steel and an outer casing. The burner passes through the center of the dome head of the flame tube, which also provides a metering orifice for the air required for primary combustion. By far the greater proportion of the air delivered from the diffuser, however, flows over the head through the gap between the flame tube and the outer casing, and enters the flame tube through secondary holes. In this way the products of combustion are diluted and temperature is kept within desirable limits. A small proportion of the air travels beyond the orifices to the annular gap at the rear end of the flame tube, thus maintaining a heat-insulating layer of relatively cold air. Two of the combustion chambers, spaced some distance apart, contain bosses for injection-type igniter plugs, and the individual chambers are interconnected so that, after ignition, the flame can spread to all the chambers.

The turbine group consists of the nozzle-junction pipe assembly, the static blades, and the turbine wheel. The nozzle-junction pipe assembly, which acts as a collector of the combustion gases before they are guided by the static blades to the turbine blades, is supported by a diaphragm mounted on the rear bearing housing. The turbine disk incorporates an integral hub shaft which is splined to an extension shaft at the rear end of the main shaft. The blades, which are secured to the disk by "fir-tree" roots, rotate within the turbine shroud ring attached to the static-blade ring, which in itself is attached to the nozzle-junction pipe assembly. The turbine shroud assembly is located by a cylindrical drum bolted between the center casing and the nozzle-junction pipe assembly. This drum also transfers loads from the exhaust cone to the center casing. The exhaust-cone assembly, which is made of stainless steel, consists of inner and outer cones, the propelling nozzle being attached at the rear end of the latter. The outer cone is surrounded by a cowling, welded in position to form a heater muff through which air can be passed, and used for warming the cabin or gun mechanism. The air leaves the turbine wheel in an axial direction and is directed and expanded in the annular passage between the two exhaust cones, issuing through the nozzle to form the propulsive jet. A thermocouple in the neighborhood of the jet enables the pilot to control the engine temperature and keep it within its operational limitations.

The wheel cases are mounted at the top and bottom of the air-intake casing. The various auxiliaries contained in these casings are connected to the main shaft through gear trains and lay shafts located inside two of the radial arms. The top wheel case carries the mounting flange for the starting motor, and con-

tains the cabin supercharger for use when the cabin is maintained under pressure; the air compressor for the brakes; a 1500-watt, 24-volt generator; a vacuum pump; and the engine speed-indicator generator drive. The bottom wheel case carries the mounting flanges for the fuel pumps and hydraulic pump; and the oil sump, containing a gear-type pump, is attached to its lower side. Metering pumps supply a measured quantity of oil to the front and rear bearings.

Oxygen

RECENT developments in oxygen production and a re-evaluation of the potential uses of oxygen in the gas industry in light of present-day techniques were presented by Dr. J. Henry Rushton, head, department of chemical engineering, Illinois Institute of Technology, Chicago, Ill., and Dr. Charles R. Downs, member A.S.M.E., consulting chemical engineer, New York, N. Y., at a meeting of the Technical Section, Joint Production and Chemical Committee Conference of the American Gas Association, held in New York recently.

PRODUCTION OF OXYGEN

Air liquefaction and rectification is the basic process considered most suitable for large-scale oxygen production. The development of low-pressure processes for producing gaseous relatively pure oxygen (95 to 98 per cent) have been developed in recent years in Germany, and during the war by the National Defense Research Committee, Office of Scientific Research and Development, in this country. The objective of most recent improvements has been to devise systems to utilize low-pressure, high-capacity, high-speed compression and refrigeration equipment, and to remove carbon dioxide and water efficiently from low-pressure air. The prevention of acetylene accumulation in the systems has received important consideration.

The essential features of any so-called mechanical method for separating oxygen from nitrogen of air are as follows: Air compression; air purification; a refrigeration mechanism; heat exchangers to apply the refrigeration and to conserve heat; and finally, distillation equipment to fractionate the air for the separation of oxygen.

There are now available for air compression large high-speed rotary and centrifugal compressors operating at thermodynamic efficiencies of approximately 85 per cent. Several of these units are now in commercial operation in this country compressing 25,000 cfm at compression ratios of about 1 to 2.7. These compressors do not require lubrication in parts in contact with the compressed air and thus are advantageous for oxygen production. Discharge pressures up to 95 psig can be achieved.

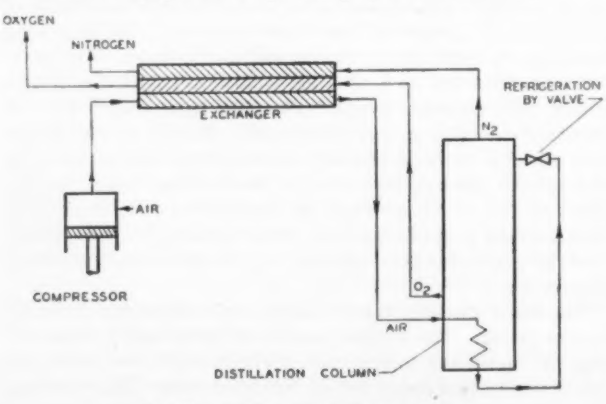


FIG. 1 LINDE HIGH-PRESSURE CYCLE

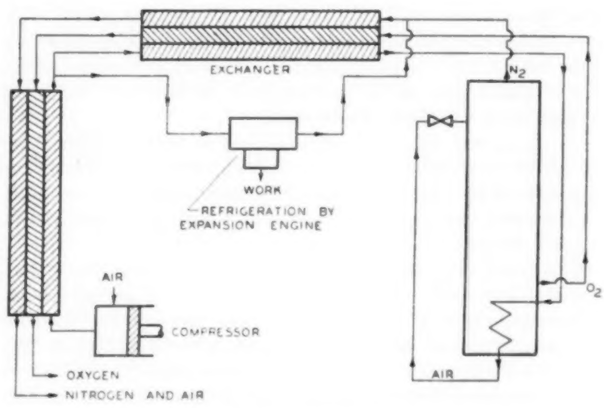


FIG. 2 CLAUDE LOW-PRESSURE CYCLE

Air can be liquefied at moderate pressures in the neighborhood of —280 F and any substance in air which will liquefy or freeze at temperatures higher than the liquefying temperature of air must be removed else they will be condensed and frozen and plug up the low-temperature processing equipment. Water will condense whenever its dew point is reached and will be frozen at temperatures of 32 F and lower. In low-pressure cycles gaseous carbon dioxide is condensed to a solid at temperatures in the neighborhood of —240 F. Various hydrocarbons will condense to liquid when their dew point temperatures are reached. For the hydrocarbons referred to these temperatures are quite low.

In the conventional and relatively high pressure cycles, water vapor and carbon dioxide are removed by absorption or chemical means and it is necessary to provide processing equipment and a continued supply of chemicals for removal of these two substances. It has been found possible in the newer low-pressure processes (up to approximately 100 psi) to combine the function of heat exchange and air purification in the same piece of equipment.

The device by which refrigeration is produced in low-pressure oxygen plants is the expansion engine. These engines use the process air itself as the refrigerating fluid. Rotating engines operating at high speeds have been operated successfully in this country for the past three years and a number are now under construction. The thermodynamic efficiency of these expanders is in excess of 80 per cent. They are easily built in small size to handle very high gas flows. For example, one expansion wheel $6^7/_8$ in. in diameter rotating at 22,000 rpm has produced refrigeration at a rate of 140,000 Btu per hr at 82 per cent efficiency at approximately liquid-air temperature level.

Compact and highly efficient heat exchangers have been developed for applying low-temperature refrigeration and for serving as continuous air cleaners.

Two elementary cycles by which air can be liquefied and fractionated are the Linde and Claude cycles.

The elements of a Linde cycle are shown in Fig. 1. This is essentially a high-pressure cycle utilizing compressed air at several hundred psi up to 3000 psi, and refrigeration is obtained at the expansion valve where high-pressure air is throttled into the distillation column. Air is cleaned by equipment placed between the compressor and heat-exchange system.

The Claude cycle is essentially a low-pressure cycle operating at pressures up to several hundred psi and is illustrated in Fig. 2. Refrigeration is achieved by an expansion engine where the low-pressure air is expanded to a pressure only slightly higher than atmospheric, under such conditions that energy is removed in the form of work. The air is cooled during the expansion and this expanded air is then used to cool air to be processed

for oxygen removal. Air-purification equipment can be used in this cycle between the compressor and heat exchanger but air purification can also be accomplished within the heat exchangers when their construction is such that they can be operated in a reversing fashion.

The basic cycle for low-pressure oxygen plants developed by the National Defense Research Committee during the war is shown in Fig. 3. This cycle operates without chemical clean-up, purifying the process air from water, carbon dioxide, and hydrocarbons to a dew point of approximately —250 F, and practically all of the refrigeration is obtained by the use of an expansion engine.

USE OF OXYGEN IN THE GAS INDUSTRY

The complete gasification of coal, with maximum retention of its heat in the gas, has long been a goal of the gas industry. For the past 12 years processes have been in operation in Germany for the manufacture of city gas by continuous processes using oxygen. In these operations using oxygen, continuous and complete gasification of coal or coke is accomplished at high thermal efficiencies. Temperatures of the fuel necessary to obtain reaction with steam can be achieved by using high-purity oxygen, injecting it into the fuel bed along with the steam. The exothermic heat of reaction of carbon with oxygen can be made to balance the heat required to maintain the carbon-steam reaction. From such an operation a gas results consisting essentially of carbon monoxide and hydrogen, the relative amounts depending on the feed ratio of oxygen and steam and the temperature and pressure of the operation.

Much publicity has been given to the underground gasification of coal, which was suggested many years ago, but first intensively studied by Russian technologists and presently under investigation in the United States. However, underground gasification should be more suitable for power generation than for the production of city gas or gas for chemical-synthesis operations. For power purposes integration with steam generators or gas turbines may be indicated. Geological considerations would include not only the structure of the coal deposit but also the sulphur content of the coal, because of the added cost of removing sulphur from the gas whether the gas is intended for fuel or synthesis operations. Economic considerations would indicate that the most suitable location would be where the density of the gas-consuming population is high; where the coal seams are too thin for cheap mining; where large investments have not been made for mechanized mining equipment or where such facilities cannot be used.

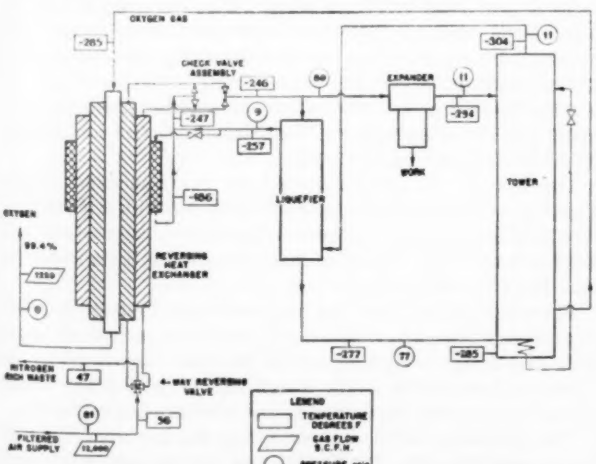


FIG. 3 BASIC CYCLE FOR LOW-PRESSURE OXYGEN PLANTS

At the present time, two large oxygen plants are being designed for production of oxygen to be used in synthetic-liquid-fuel manufacture. The plants are to be erected at Brownsville, Texas, under the direction of Hydrocarbons Research, Inc., and associated companies, and in the Hugoten area by Stanolind Gas and Oil Company. They will be the largest completely low-pressure oxygen plants in the world and each will produce approximately 2000 tons of oxygen per day. Another large oxygen plant is being built by the Air Reduction Company in the Pittsburgh area for steel operations and it is anticipated that this plant will give the first practical data in this country on the potentialities of the use of oxygen in blast furnace and other steelmaking operations. (See "Oxygen Plant," page 778.)

An important question now facing the gas industry is whether these oxygen costs will be low enough to be attractive for gasmaking.

Centrifugal Compressor

A SUCCESSFUL run-in test of a centrifugal compressor, said to be the first ever to use propane in a refrigeration cycle, was completed recently by Carrier Corporation, Syracuse, N. Y.

Set up as a self-contained, complete package, including compressor and turbine as well as auxiliary oil pumps and oil coolers, the new centrifugal covers a floor area 5 ft wide × 15 ft long. It was reported that the unit assured not only great spacesaving as against reciprocating compressors, but lower original and maintenance costs as well. The refrigerant—propane—is an inexpensive by-product readily available in all refineries.

The first propane centrifugal, having passed its test, will be installed by the Atlantic Refining Company in its new Point Breeze, Pa., plant by E. B. Badger & Sons Company, of Boston, Mass. Atlantic will use the machine in its dewaxing process, in which oil is chilled to approximately 25 deg below zero in order to congeal and remove the wax base.

The Atlantic unit will have five stages. It is nominally a 2000-cfm compressor and operates between the levels of 21 psia inlet pressure and minus 22 deg and discharges into a condenser at 195 psia. The compressor runs at a speed of approximately 9400 rpm and requires 975 bhp. It will be direct-connected to a 1085-hp steam turbine and will operate on 600 lb and 700 deg steam with 15 lb exhaust.

Other Carrier gas compressors in this same line range in capacity from 1000 to 30,000 cfm. The smaller-size units can be furnished with three, four, or five impellers on one shaft. The larger units can be furnished with three or four impellers on one shaft. Both large and small units operate below the first critical speed and are designed to handle up to 8500 hp in a single casing.

They are adaptable to any temperature level from minus 150 deg up to 100 or 150 deg inlet temperature. The pressure range is from extremely high vacuum up to inlet pressures of from 100 to 200 psi.

Electroless Plating

A NEW method for plating nickel and cobalt on metal surfaces without the use of electric current has been developed by Abner Brenner and Grace E. Riddell of the National Bureau of Standards. This process, known as electroless plating, is brought about by chemical reduction of a nickel or cobalt salt with hypophosphite in hot solution. The reaction is catalytic, and under the prescribed conditions of concentration and pH, no plating occurs unless certain metals, such as steel

or nickel, are introduced in the bath. The reduction then occurs only on the surface of the immersed metal with the production of an adherent coating of 93 to 97 per cent purity.

Photomicrographs of deposits obtained in this way show both a laminar and a columnar structure, similar to bright-nickel electrodeposits. The electroless deposits are of good quality—sound though brittle and usually bright. Since they can be made as hard as tool steel, the method may prove useful where hard wear-resistant surfaces are required, as in bearings. The process is particularly applicable to the plating of recesses, irregular-shaped objects, and enclosed areas such as tubes, where a centered internal electrode with special current leads would be needed in electroplating.

The equipment is simple and more easily assembled than that required for electroplating. No generators, rheostats, special racks, or contacts are necessary. Small parts which cannot be barrel-plated economically are readily plated by the electroless process if suspended by a string or in a bag affording ample exposure of the metal surface to the solution. There is no need of constant motion, as in barrel plating, since current distribution is not involved.

While electroless deposits of cobalt and cobalt-nickel alloys have been obtained only from ammoniacal solutions, nickel can be deposited from either acid or alkaline solutions. The reactions, requiring a temperature above 90 C, are given in the following equations (in which cobalt may be written for nickel): $NiCl_2 + NaH_2PO_2 + H_2O \rightarrow Ni + 2HCl + NaH_2PO_3$ or $NaH_2PO_2 + H_2O \rightarrow NaH_2PO_3 + H_2$. The first reaction is the important one, resulting in the deposition of nickel; the second reaction tends to lower the efficiency of the process through oxidation of the hypophosphite.

A unique feature of the electroless process is the catalytic initiation of the reaction by the following metals: Iron or steel, nickel, gold, cobalt, palladium, and aluminum. Unless one of these metals is introduced into the solution, no reaction takes place. Once started, the reaction continues at the metallic surface and only rarely occurs in other parts of the bath. For this reason the containing vessel should be of glass, plastic, or other noncatalytic material.

Objects to be plated are cleaned by any of the accepted procedures and are given an acid dip before being suspended in the hot solution. The rate of deposition is about the same as in barrel electroplating, ranging from 0.0002 to 0.0008 in. per hr, depending upon the type of solution used. During the process the pH must be kept within a certain range, and if the operation is of long duration, the nickel salt and hypophosphite are replenished at regular intervals.

Electroless plating on noncatalytic metal surfaces may be accomplished in two ways. If a film of palladium or rhodium of nearly monatomic thickness is first applied by chemical replacement on a noncatalytic metal, deposition of nickel or cobalt will occur on the activated surface. Electroless plating of copper may be carried out in this way. A second method of initiating the reduction is to bring a less noble metal, such as iron or aluminum, in contact with the noncatalytic metal while it is immersed in the hot electroless solution. Once the process has been started, it continues because of the catalytic action of the initial deposit.

As formed, the electroless nickel deposits are brittle but become ductile when heated. These deposits are harder than the ordinary electrodeposited nickel and upon heating their hardness is still further increased. This is in contrast to the behavior of "hard" electrodeposited nickel, which has high initial hardness but softens upon heating. The hardening may be explained as "precipitation hardening," probably of phosphides.

The adhesion of the nickel deposit to mild steel is such that it cannot be flaked off by bending, but on high-carbon steel this property is less satisfactory. In salt-spray tests on steel coated with 0.0002, 0.0005, and 0.001 in. of electroless nickel, in comparison with similar panels coated with electrodeposited nickel, the protective value of the types of coatings was virtually the same. However, the electroless cobalt does not compare so favorably with electrodeposited cobalt.

The yield or efficiency of the reduction based on the decomposition of hypophosphite is 37 and 66 per cent for nickel and cobalt, respectively. About 2 grams of nickel or nearly 4 grams of cobalt are reduced by 10 grams of sodium hypophosphite. Because of the moderate yield and the present high cost of sodium hypophosphite, the process is expensive. Extensive commercial use of electroless plating is thus dependent upon a reduction in the price of this chemical.

Heavy-Duty Steel Rail

THREE new designs of heavy-duty steel rail of greater strength and wearability, assuring safer operation, smoother riding, and economy of maintenance are reported to have been developed by the Pennsylvania Railroad and are now being used wherever new rail is installed on the main lines under the railroad's 1947 improvement program. Each of the three types is designed to meet a specific operating condition.

Several years of research, development, and experimentation went into the design and testing of the new rails, with tests conducted both at Altoona, Pa., and on the railroad under actual operating condition.

A tiny gage, only one fourth the size of a postage stamp, consisting of a grid of fine wire enclosed between two sheets of thin paper, was used in measuring the actual effect on the rail of passing trains during the operating tests. The test engineers cemented the gage to the rails, connected it to an electronic circuit, and ran the current thus set up through amplifier tubes. The stronger current was then made to actuate an oscillograph, which in turn deflected a beam of light on a moving photographic film to record the actual behavior of track when trains pass over it. From data gathered in this and other ways, the new designs were worked out to achieve a better balance in the proportions of rails.

Two of the new rail designs are improvements over types which have proved their basic worth during hard wartime usage under record-breaking freight and passenger traffic. The third is a new intermediate design. All look much like the rail now in service except that the metal is better utilized by means of longer sweeping curves connecting the underside of the railhead on which the wheels run, with the "web" or vertical middle part of the rail to give added strength. The upper portion of the web itself is thickened better to resist the forces of trains rounding curves.

The new rail for track carrying the heaviest traffic weighs 155 lb per yd, compared with the 152-lb rail which it replaces. The additional steel, together with the new design of the railhead and the web, is said to make the new rail the strongest that has ever been made.

For track which does not have sufficient tonnage or traffic density to require the heaviest rail, engineers have developed a new rail design weighing 140 lb per yd. Compared to the former second-heaviest rail, weighing 131 lb, the new design has a thicker head, thicker web, and is somewhat higher.

The third new rail design, weighing 133 lb per yd, is an improvement over the 131-lb rail now in use and while only slightly heavier than the rail it replaces, a thicker head and newly designed web give longer life and better service.

X-RAY LABORATORY

A new x-ray laboratory embodying modern techniques for examining steel, aluminum, brass, and other metals used in rails, locomotives, cars, and other equipment to assure increased safety of railroad operation was also announced recently by the Pennsylvania Railroad.

The laboratory, located at Altoona, Pa., includes a 250,000-volt mobile x-ray machine mounted on automobile wheels so that it may be used either in the specially constructed laboratory building, or, when a large object such as a locomotive boiler is to be examined, in the adjacent construction and repair shops. It can examine the internal structure of metals as much as three inches thick.

The laboratory building is equipped with 18-in-thick solid concrete walls to permit the use of x-ray equipment as powerful as 2,000,000 volts.

X-ray testing of metals is particularly helpful in examining welded metal parts, because it permits the technicians to examine the weld in minute detail without damaging the metal. This is especially important because of the increasing use of welding as a more efficient means of constructing high-pressure locomotive boilers, frames for Diesel-electric locomotives, fabricated cylinders for steam engines, passenger- and freight-car truck frames, and other parts. Any defect in a welded joint is found and corrected immediately.

Further plans are for the installation of a permanently mounted x-ray machine of 1,000,000-volt capacity in the laboratory building.

Unique Assembly Plant

THE first of two new postwar assembly plants to go into operation, the Chevrolet-Flint unit, was opened recently, revealing a new method of handling car and truck chassis in a process known as "suspended assembly," according to *Steel*, June 30, 1947. Instead of the chassis progressing along the assembly line on a floor-level conveyer, it is hung from an overhead monorail conveyer, bringing the work to the employee at bench level and permitting right-side-up assembly of the chassis and free access from all sides. Of the $4^1/_2$ miles of conveyers installed in the plant, only $^1/_2$ mile is of the floor type, illustrating the degree to which the overhead system has been used.

The layout includes ten buildings located on 104 acres of property just outside the Flint city limits. Floor area totals 1,250,000 sq ft, including the Chevrolet operations and those of an adjoining Fisher Body unit. There are two passenger-car and one truck-assembly lines.

Unique in plant layout, according to Chevrolet engineers, is the final assembly-line "switch," with the lines progressing from dual body drop position. A single chassis line supplies the dual final lines, which are paced at one half the speed of the chassis conveyer.

Finished cars are driven off assembly lines onto a pneumatically operated parallelogram which automatically checks and trues wheel alignment. At the same station, headlights are adjusted with the aid of photoelectric cells, after which vehicles are driven onto a test track behind the plant for preliminary road check.

Another "first" claimed for the plant is the "power-and-free" conveyer system employed at several points. In the "power" phase, the power chain for the conveyer system makes direct contact with and moves the carrier. In the "free" phase, the chain loops up away from the carrier and permits it to be moved by hand, thereby enabling assembly workers to pace the rate of flow.

An elevator device at the start of the line is another innovation. An empty frame carrier is brought into position at a level higher than the conveyer itself. It is moved into a rack which automatically lowers it to the proper position at the start of the line. A similar elevator operates at the end of the chassis assembly line to lift the empty carrier to the return line.

Furnace Operation

THE limitations of increasing the hot-blast temperature and the use of an oxygen-enriched blast in furnaces were discussed in a paper presented by William Bennett, member A.S.M.E., assistant superintendent, Carrie Furnaces, Carnegie-Illinois Steel Corporation, Munhall, Pa., at a meeting of the A.I.M.E. in Cincinnati, Ohio, April 23, 1947.

He stated that in looking over the matter of utilization of hot-blast temperatures it can be found that some furnaces operating on hard lean ores are unable to use blast heats in excess of 800 to 900 F; others on soft Mesabi ore working with a maximum of 1000 to 1100 F blast temperature; and still others on similar soft ores utilizing heat at 1300 to 1400 F. Also, some furnaces are operating on prepared burdens with low coke rate and high production, utilizing blast heats as high as 1500 to 1600 F, while other furnaces operating on rich-ore burdens with very low coke rates using 1400 F maximum heat.

The generally accepted explanation for these differences is that the sum of the support offered by the blast, the friction of the walls, and the viscosity of the plastic zone equal the weight of the charge and therefore the stock cannot move. The viscosity of the materials in the plastic zone depends on their chemical and physical composition and the heat quantities to which they are subjected. The wall friction varies with the physical nature of the stock and the cleanliness of the wall. Lastly, the support offered by the blast depends on the volume of the blast products, their density and temperature, and the free path available at this temperature through the stock.

It is the relationship between the amount of free path offered through stock and the volume of gases to be forced through it that is believed to be the controlling factor in most furnace irregularities connected with blast temperature or oxygen enrichment. It may be that limitations of the use of higher blast heats are related directly to the free path offered the blast products up through the different levels of the stock which varies with their temperature at these successive levels. Whether or not higher blast heats can be utilized in this regard will depend on whether the added heat in the hotter blast can be absorbed in the hearth and bosh (through increased direct reduction of FeO, SiO_2, or other compounds) or merely raises the temperature of the blast products, thus increasing their velocity and possibly further affecting the effective free path through the charge by driving the fusion zone higher and into a smaller cross section of the furnace.

It has commonly been observed that, other things being equal, lean slags permit the utilization of higher heats than do limey slags. It is believed that this is because leaner slags melt and run down out of the way more readily than limey slags.

Furnaces with high rates of direct reduction, such as ferromanganese furnaces, can utilize maximum blast heat. It is believed the reason for this is that when extra heat is added to the hearth of such a furnace in the form of higher blast heat, the temperature of the hearth and the blast products is not raised appreciably because the extra heat goes to promote more high-temperature reactions. There is also a large free path present in this practice as compared to standard basic iron due to the large amount of coke in the burden.

Furnaces on standard basic iron, using soft Mesabi ore, may or may not utilize high blast heats, depending on the extent to which direct reduction is involved. Such furnaces are generally blown with maximum wind and if they operate with a low coke rate and low direct reduction, there is not much hope of utilizing high blast heats for the following reasons: (1) At maximum wind rate, there is no excess free-path area; (2) on soft ores and low-coke-rate operation, voids in the charge are likely to be already at a minimum. Further reduction in the coke rate may result in too tight a burden, necessitating a "pull" of wind and heat to correct; (3) where there is only a small amount of direct reduction in the hearth, additions to the blast heat can only result in raising the temperature of the blast products and thus of the stock, and in driving the fusion zone into a higher part of the furnace.

Another cause of furnace irregularity is the influence on furnace action of channeling of the gases in the stock column because of dirty or irregularly eroded walls, segregated stock, and faulty bell action. While it is not denied that variability in slag-forming rates may and doubtless does initiate many furnace irregularities, it is felt that more often shifting gas flow is itself the initiator of these irregularities in slag-forming rates.

Some of the things that would probably have to be done to utilize higher blast heat would be: (1) Induce more direct reduction in the hearth; and (2) provide greater free path for the furnace gases through the stock by the use of sized material, use of leaner slags or at least more easily melted slags, change of furnace design, use of strong coke, and the use of beneficiated material such as sinter.

The use of oxygen-enriched blast is in many respects almost identical in its effects. Both increase the temperature of the available heat in the hearth without much altering the quantity of heat. A notable point to mention in connection with oxygen enrichment is the fact that for the same amount of carbon burned at the tuyères, the oxygen-enriched blast actually brings less heat to the hearth than the air blast when both are preheated to the same temperature. Some of the factors which limit the amount of oxygen enrichment are: (1) Heat leaving the hearth must equal the shaft requirements; (2) top heat must be maintained at a minimum of 230 F; (3) retarded slag formation may cause irregular working; (4) lumpy material (ore and stone) giving wide variations in amount of direct reductions; and (5) furnaces in which the coke rate is already low. At the present time, however, perhaps the main limitation on the use of oxygen is still the financial consideration.

Semicircular Lamp

A NEW semicircular fluorescent lamp that is said to provide more light than a 50-watt incandescent lamp, but consumes only about one third the power, has been introduced by Westinghouse Lamp Division. Designated "Circlarc," the new lamp is ideal for table and floor lamps, for wall and ceiling fixtures, for merchandising displays, and for interiors where the lamp itself will add a decorative dash.

The lamp plus its ballast, required to operate all fluorescent lamps off regular lighting circuits, will sell for about one third the price of the circular fluorescent lamp and its ballast. The ballast for the Circlarc is one third as large and only one fifth the cost of the circular-lamp ballast.

It is an 18-watt tube curved to form a half circle 12 in. in diameter and has a useful life expectancy of 2500 hr at 3 hr average burning for each start. This is the same burning life as for the circular lamp and two and one half times longer-lived than the 50-watt incandescent bulb. A two-pin plastic base at each end of the semicircular lamp connects it to the electric current. The base pins are located 45 deg to the plane of the lamp which arrangement allows the pins of the two opposing lamps to overlap and reduces the thickness of the two-lamp holder to a minimum.

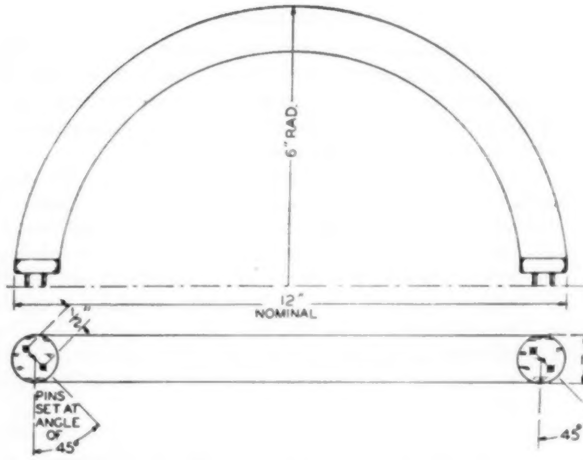


FIG. 4 DETAIL DRAWING OF 18-WATT SEMICIRCULAR FLUORESCENT LAMP

Artificial Pearls

ARTIFICIAL pearls, generally much less expensive than the natural or cultured pearls, are surprisingly close imitations and are one of the most popular adornments, according to an article in the *Industrial Bulletin* of Arthur D. Little, Inc., July, 1947. Research is under way to make them even less expensive and more attractive, and a mechanized process for obtaining the pearl essence which characterizes them is under development.

Artificial pearls are usually solid spheres of "alabaster" glass coated with lacquers containing pearl essence, obtained in this country from the scales of herring. Each scale contains tiny crystals of "guanine" which appear like thin transparent blades. When several coats of lacquer containing the essence are skillfully applied, the reflection of light in various directions gives the lustrous appearance associated with real pearls.

The art of removing pearl essence from fish scales dates back several hundred years; the best essence is now produced in the United States. The scales are collected from various sources, with the best quality obtained from the bottoms of fishing boats supplying the eastern canneries. The established extraction processes are long and involved and can cause waste from putrefaction and mechanical injury to the delicate crystalloids. Even slight damage to the crystalloid structure of the guanine during separation from the other materials in the fish scales lowers the quality of the product.

The fish scales are carefully washed and churned in cleaning solutions, and the transparent bony structure of the scale and other undesired matter are removed by straining and repeated siphoning. The crude essence is then washed and extracted several times with organic solvents, each step being followed by centrifugal separation. The purified essence is then suspended in a clear lacquer for use. A new mechanical process involves washing and centrifuging, but eliminates the time and expense of chemical extraction. Since the process is said to utilize the slightly damaged fish scales, it is expected that larger amounts of pearl essence may be obtained at less cost.

Fish scales contain yellow protein matter which must be re-

moved to an exact degree. The balance between too much protein, resulting in a deep yellow color, and too little, resulting in a high metallic luster, is extremely delicate. It is difficult to determine by sampling whether the essence will produce an acceptable finish, and quality may vary from batch to batch. Research is under way to develop a method of quality control to permit greater uniformity of the product.

Alabaster glass beads were first made in Czechoslovakia, but the Japanese captured a large portion of the world market. Because of labor costs, the United States has never produced any appreciable quantity of the beads, even during the war. Beads of transparent plastic have been used during the past eight years, in addition to the regular glass beads. New lacquer formulations and polishing methods for iridescent pearls are also under investigation, since some pearls made by present methods tend to darken when exposed to sunlight.

In coating the beads, each bead is impaled on a toothpick, hand-dipped in a suspension of pearl essence in lacquer, rotated for even flow of the lacquer over the surface, and re-dipped until a suitable coating is achieved. After dipping, the beads are dried and buffed. Most of the cost of a simulated pearl necklace is in the large amount of hand labor involved. For the best necklaces, which may sell for as much as $100, the individual pearls are carefully matched for color, luster, and size.

For other applications, pearl essence may be incorporated in a lacquer coating on metal or other materials. It is used for toilet articles, handles for cutlery, decorative coatings generally, and in molding powders and plastics. An interesting application is in combination with methacrylate resins for the production of beads by injection molding.

5000-Hp Electric Locomotives

TWO single-cab electric locomotives, said to be the world's largest, each a 360-ton 101-ft-long unit developing 5000 hp, have been built especially for the Great Northern Railway by the General Electric Company.

Designed primarily for heavy mountain service, this Class B-D-D-B 11,000-volt, 25-cycle, single-phase motor generator locomotive has a continuous rating of 5000 hp at the rail with 119,000 lb tractive effort at a speed as low as 15.75 mph. For starting and acceleration, tractive efforts up to 180,000 lb are available. All weight is on drivers, every axle is motor-driven, and maximum regenerative breaking is provided.

The continuous-braking horsepower provided through regenerative braking is approximately 5750 hp between 16.5 and 65 mph. This braking power in conjunction with the great weight on drivers makes it possible in many cases to handle heavy trains on grades without the use of the train air brakes, with a resultant decrease in wheel and brake-shoe maintenance.

The locomotive is equipped with two 5-unit motor-generator sets, one set mounted in each end of the apparatus compartment. Each set is driven by a 25-cycle, 750-rpm, single-phase synchronous motor, both motors taking power from the trolley through a single transformer, and delivering direct-current power to the 12 traction motors. In addition to driving the traction generators, each synchronous motor drives a traction-generator exciter and a regenerative exciter. The motor generator sets are started by applying reduced direct-current voltage to the generators, using them as starting motors. The regenerative exciters provide traction-motor excitation during regeneration and motor field control during motoring. Generators may be connected in parallel for hauling heavy trains at lower speeds or series-parallel for high-speed passenger service.

The single transformer, situated in the apparatus compartment between the two motor generator sets, is an 11,000/1350-volt, Pyranol-filled, air-cooled unit. Power is drawn from an overhead trolley through spring-raised, air-lowered, double-shoe-type pantographs.

Twelve specially designed 300/600-volt direct-current, series-wound, axle-mounted traction motors power the locomotive, one motor per axle. Each motor is rated 500-hp for traction, both hourly and continuous, with FS-1 rating of 1150-amp hourly and 1050 amp continuous. Geared for speeds up to 65 mph, each motor has a single-reduction solid gear with solid pinion. Cooled by forced ventilation, each motor receives 2300 cu ft of air per min from high-capacity traction motor blowers located forward of the motor-generators in the apparatus compartment.

Two 3-unit motor-alternator sets, placed in the nose compartments of the cab, furnish power for the auxiliaries. Each set includes an 85-hp, 1475-rpm, single-phase induction motor driving a 62.5-kva, 123-cycle alternator, and a 15-kw, 75-volt direct-current generator. The direct-current generator supplies control power, starts the synchronous motors by motoring the traction generators, and charges the battery while the 123-cycle alternator powers the traction-motor blowers.

Also located in the nose compartment, two 2-stage, alternating-current motor-driven air compressors have a displacement of 150 cfm and maintain a reservoir pressure of 130 psi.

The control stand, conveniently located at the left of the engineer's position in the cabs, mounts the master controller, selector and reverser handles, and regenerative braking controller. The instrument panel is forward of the engineer, and the main control equipment is housed in compartments directly behind the operator's cabs.

A motor-element pantograph relay and ground-switch system provide primary-circuit protection including the high-voltage windings of the main power transformer and the low-voltage alternating-current circuits.

Overspeed protection equipment functions at speeds in excess of 65 mph, and wheel-slip relays and ground protection are also provided.

The double-end superstructure is of all-welded construction, fabricated throughout from steel shapes and plates. Operators' cabs, designed as an integral part of the locomotive structure, give maximum operating visibility and comfort.

The locomotive has two 4-axle motorized main trucks and two 2-axle motorized guiding trucks. The main truck frames,

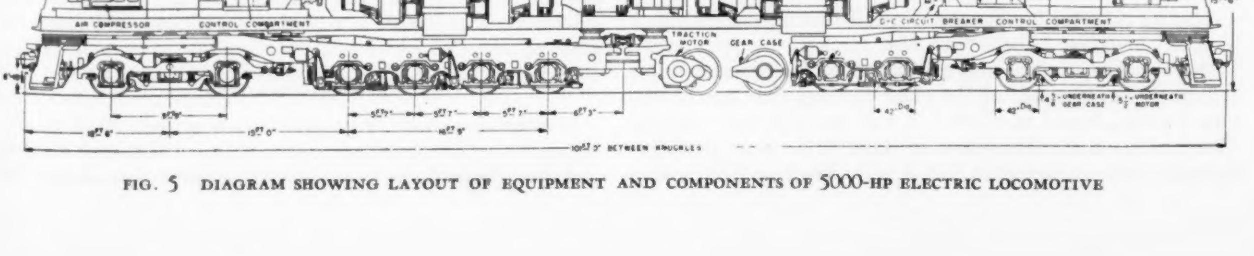


FIG. 5 DIAGRAM SHOWING LAYOUT OF EQUIPMENT AND COMPONENTS OF 5000-HP ELECTRIC LOCOMOTIVE

carried on the guiding trucks, extend over beyond the guiding trucks to support rubber-type draft gear consisting of swivel-butt, type E couplers with alloy-steel knuckles.

Insulation Material

DEVELOPMENT of a scientifically unique form of matter into a spacesaving insulant is increasing household refrigerator and freezer capacity up to 60 per cent without adding to outside dimensions, according to an announcement made by Monsanto Chemical Company recently.

It is claimed that the capacity of the average household refrigerator is being increased from $7^1/_2$ cu ft to 11 cu ft by cutting down wall thicknesses normally taken up by bulky insulating materials. A refrigerator capacity of 5 cu ft is increased to 8 cu ft, and a 9 cu ft capacity is increased to about 13 cu ft. The capacity of the average household freezer is increased from 5 to $9^1/_2$ cu ft.

Chemically the insulant (described by chemists as an aerogel and known as Santocel) is 6 per cent silica and 94 per cent air. Physically, it is a fine, free-flowing white powder, from which all liquid matter has been removed without destroying the microscopically-small honeycomb of individual cells composing the substance.

It is reported to be the only product with a thermal conductivity lower than that of still air, heretofore considered the most efficient theoretical insulant. The aerogel in itself, chemists said, is a scientifically unique form of matter.

The first step in the production of this insulant is the reaction of sodium silicate and sulphuric acid to form silica jelly. This jelly has two phases: A liquid phase which is water and a solid phase which is silica.

Through the use of high temperatures and pressures, the water is removed from the silica jelly and is replaced by air without destroying the gel structure. It is the maintenance of the gel structure that gives the material its remarkable insulating properties. In the structure, pore spaces which contain the air are smaller in diameter than the average distance a molecule travels in air before striking another molecule. Thus molecule motion and consequent heat transfer is reduced.

Lumber

IN a paper which he presented at the Wood Industries Conference of The American Society of Mechanical Engineers, held in Madison, Wis., June 12–13, 1947, L. W. Smith, wood technologist, U. S. Forest Service, Washington, D. C., discussed the technical phases of the grading, inspection, and specification of lumber.

LUMBER GRADING

Lumber grading consists of a visual examination in which each piece is assigned to a grade as determined by the characteristics and limitations prescribed in the grading rules for the particular species involved. Grading rules in use today are sufficiently explicit to enable good graders, properly supervised, to check each other within an allowance of about 5 per cent.

Grading rules for lumber are of two distinct types, either or both of which may be used with most species.

The first type, applied to lumber intended for remanufacture, defines grades in terms of the clear cuttings that can be obtained from a board or plank. A rule may say, for example, "Each piece shall contain not less than 50 per cent clear face cuttings, none smaller than 3 × 4 in." The so-called cutting rules are used for the grading of hardwood and softwood factory and shop lumber.

The second grading rule contemplates the use of each piece without further remanufacture than fitting and perhaps trimming. Ordinary construction lumber—beams, joists, and boards—are the best examples of these piece grades. The extent and size of the various natural characteristics and acquired blemishes determine the grade of lumber graded under this system. Rules may be relatively simple as in the case of common boards or quite detailed as in the case of structural stress grades. In each case, however, it is the surface characteristics, not the proportion of clear lumber, that determines the grade.

Some pieces of lumber may be graded by either system but, in general, all grading rules are of one or the other basic type.

The quality selection of lumber does not, of itself, involve a consideration of standard widths, thicknesses, and lengths, but the importance of size to the efficient use of lumber is so great that size standards are an integral part of lumber grading.

American Lumber Standards for softwood lumber include not only standards of size, pattern, and terminology, but also set forth in considerable detail the basic quality standards in accordance with which grading rules for softwood species have been developed.

Modern grading rules for softwood lumber use substantially the same nomenclature. All follow the same general progression of grades from best to poorest. Those differences that do exist may be accounted for by inherent species characterisitics which make one species more desirable for a greater variety of uses than another.

The actual formulation of grading rules is done by the regional lumber manufacturers' association or their respective grading bureaus. Each association is concerned with a species or a group of species that grow together or are logged in the same geographical region.

Proposals for new or revised rules are considered from various viewpoints including that of the user. Such proposals, if workable and not in conflict with American Lumber Standards, frequently become translated into formal grading rules. For example, structural stress grades were not invented by lumber manufacturers, but were developed by the Forest Products Laboratory and within the past 10 years have been adopted by manufacturers' associations and converted into grading rules for structural lumber.

The development of a grading system for hardwood lumber has, in a broad sense, followed much the same course as that of softwood lumber. There is, however, one important difference. Hardwood lumber has been bought principally by remanufacturers and almost invariably unsurfaced. With hardwoods there have not been so many diverse interests to reconcile as to quality and finished thickness. A government-sponsored hardwood lumber standard has not been needed. Throughout the years the grading of hardwood lumber has become centralized in an organization of producers, dealers, and users—the National Hardwood Lumber Association—which is essentially an inspection agency. It drafts and administers the grading rules for all species of hardwood lumber. New rules are prepared and old rules revised as occasion demands by much the same procedure as is followed by the softwood associations.

Federal specifications recognize the value of standardized grading rules in that they direct government procurement officers to order lumber in accordance with current commercial grading rules.

LUMBER INSPECTION

Lumber inspection, like grading, is a process of quality segregation. The terms are used loosely in the lumber industry and there probably is no generally accepted definition that dis-

tinguishes between the two. It is convenient, however, to consider grading as the original quality classification at the point of origin or shipment; the grader being an employee of the manufacturer or shipper. Inspection, on the other hand, may be regarded as a review of the work of a grader either at origin or destination by an inspector who is not employed by manufacturer or shipper.

There are several kinds of lumber inspection, the most common of which is the buyer's inspection. The proprietor of a small retail or manufacturing business usually does not make a thorough piece-by-piece inspection. Ordinarily the lumber is tallied but its general appearance is the only criterion of quality. If there is serious question of grade, a complaint is made to the shipper who in most cases makes a satisfactory adjustment. Sometimes settlements cannot be effected by this simple method, whereupon the parties concerned have recourse to association inspection.

Users of large quantities of lumber consider it unwise to rely on any such haphazard inspection. Most of them employ competent inspectors whose duty is to make a piece tally and piece inspection of lumber received. Some industries, especially the railroads, have traveling inspectors to supervise the loading of the specified quality and quantity at the point of shipment. The occasional disputes that arise are in many instances adjusted on the basis of the buyer's inspection. Some disputes have to be referred to association inspection.

There are two kinds of association inspection agencies, softwood agencies and hardwood agencies. Softwood agencies are financed by manufacturers. Their inspectors may be used to inspect and supervise the loading of lumber at origin or they may be employed to reinspect rejected or disputed material. In the first case the inspector will issue a certificate of inspection, and on request, grade-mark the lumber; in the second case he will prepare a report of grade and tally which may be used as the basis for settling the claim.

Softwood association inspectors also supervise grade-marking. Early in the development of standardized grading and inspection it became evident that if competent mill graders could be impartially supervised they could be used to certify lumber quality efficiently and at somewhat less cost than certificate inspections. Consequently grade marking procedure was evolved. Under the grade marking plan, mill graders are trained by association inspectors and when qualified are permitted to grade mark lumber for manufacturers who are licensed by the association concerned. Thereafter the grader's work is supervised by inspectors who visit licensed mills frequently. Then too, traveling inspectors in the consuming markets spot-inspect grade marked lumber to check the performance of the various grade marking mills. Grade marking is so supervised and controlled that it is considered to be a reliable quality identification. It is accepted by many buyers in lieu of other inspection.

The hardwood inspection association procedure is much the same as softwood inspection. Hardwood certificates of inspection are similar to softwood certificates and reinspection follows the same general procedure. There is, however, no provision for association-sponsored hardwood grade marking at sawmills except for the grade identification of hardwood flooring under the rules of the flooring associations.

In addition to association inspection, commercial inspection is available to purchasers of lumber. There are a number of testing laboratories and privately operated inspection agencies that will provide lumber inspection for their clients in accordance with any specified grading rule.

Government agencies at one time did their own inspecting and this may still be the practice of some agencies. Unfortunately, government inspection was not always satisfactory and after the first world war it was apparent that something was radically wrong with federal lumber procurement and inspection. About this time the whole subject of lumber standardization, grading, and inspection was receiving the attention of government and industry. The acceptance of American Lumber Standards provided the opportunity for more uniform and consistent inspection of lumber purchased by the government, and the Federal Specifications Board provided for the acceptance of grade marks and certificates of inspection in the Federal Specifications. In 1942 commercial inspection at the option of the procuring agency was included. Now federal agencies may inspect the lumber they buy or they may delegate the job to associations or agencies. However, it should be noted that the acceptance of certified or grade-marked lumber does not relieve the procuring agency of responsibility for the conformance to specifications of lumber bought. A purchase order may stipulate grade-marked lumber but the procuring agency may reject such lumber if there is doubt as to its quality.

LUMBER SPECIFICATION

The basis of a satisfactory purchase often is a good specification. Fundamentally, a specification is the buyer's way of telling a vendor what he wishes to buy.

A good lumber specification should contain the choice of species best suited to the proposed use. Where the end use is associated with a particular kind of wood the specifier has no choice. For example, a manufacturer of sycamore butcher's blocks would hardly be interested in other species. On the other hand, a critical selection of species is not necessary for such uses as ordinary light construction.

The buyer must define the quality best suited to his needs. This is accomplished by specifying a grade in accordance with the commercial grading rules for the chosen species. The selection of an appropriate grade is often a combination of its practical use and the appearance. For example, if lumber for interior woodwork is needed, almost any sound grade would be suitable from a purely utilitarian standpoint; however, in this case appearance would probably be the deciding factor and one of the finish grades would be specified. Conversely, a subfloor of high-quality lumber doubtless would present an excellent appearance but practical considerations would dictate the use of a common grade. Where strength is required the specification of lumber graded for strength is indicated.

Frequently structural designers fall into the error of basing designs on relatively high stress grades. Sections adequate for design loads at the assumed unit stresses sometimes are not large enough for the required connections. When sizes are increased to provide for bolts or other fastenings all too often the lumber grade is not adjusted to the reduced stress. The result is the specification of relatively scarce and expensive lumber of high structural quality where such material is not actually needed.

Bending strength is sometimes confused with stiffness. Bending strength is associated with species (modulus of rupture), size, and grade. Stiffness is a function of species (modulus of elasticity) and size; grade has little or no influence.

It is generally by far the best practice to specify medium-grade lumber, depending upon dimensions, particularly depth, to provide strength and stiffness.

In all cases a lumber specification should be written in terms of the standard commercial grade names. The range of commercial grades is broad enough to satisfy practically all requirements.

It is always best to use lumber dried as closely as possible to the moisture content that it will ultimately attain in service.

Dryness is best expressed in terms of a stipulated moisture content rather than by reference to the method of drying.

"Air dry" and "kiln dry" have no specific meaning in so far as moisture content is concerned.

It is also important to describe the lumber as rough or surfaced or to indicate standard workings such as flooring, drop siding, or pattern. Special working is generally best described by a simple sketch.

In addition, the vendor will need other information such as quantity, grade certification if desired, time and place of delivery, the price, and the terms of payment.

Strain Gages

THE deForest scratch-recording strain gage, which became unavailable during the war, has again been made available by The Baldwin Locomotive Works, Philadelphia, Pa.

The instrument is believed to be the smallest, lightest, and lowest-cost recording strain gage ever devised. It is self-contained, weighs less than two grams and records deformations of 0.0001 to 0.050 in. by a scratch pattern on a small polished chrome-plated target. Its principal applications have been the measurement of strains in fast-moving machine parts, as for example, airplane propellers and engine crankshafts, but it is also used to some extent in stationary structural members.

The scratch record is made by a special abrasive coating on the end of a 2-in. arm which is held on the target. The gage may be fastened to a structural member under test by such means as screws, solder, spot welds, and clamps. Attachment is made with the scratch arm parallel to the direction of strain. Deformation of the member causes longitudinal movements of the scratch arm and target relative to each other while the arm gradually sweeps across the target. Although the gage does not measure torsional strain quantitatively it indicates its presence and frequency in terms of longitudinal vibration.

The gage is mounted with the scratch arm centered on the target. When ready for test, the arm is pushed to one side or the other of the target, thus marking zero lines across which the scratch records are made and setting up a restoring force in a fulcrum spring in the arm. One part of the target presses down on the arm with sufficient force to hold it in place when the test surface is static but permits creeping toward center when deformation of the member causes longitudinal movements in the gage. The rate of this movement can be adjusted to make closely packed or spread-out records. Two records can be made on each target, and by using removable half-targets, several records may be made before removing the gage.

The scratch record may be examined and measured under a filar eyepiece microscope at magnification of 100× to 250× or photographs up to 1500× may be made.

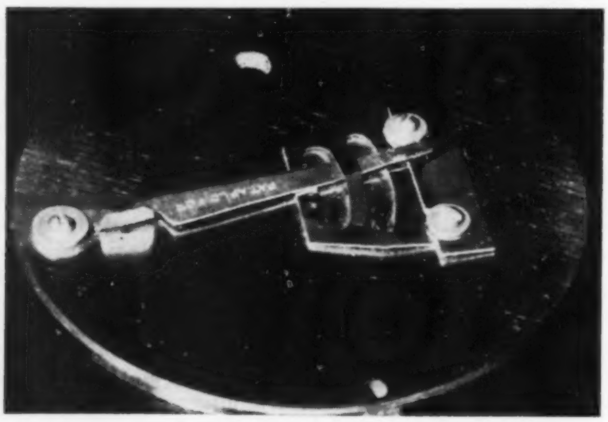


FIG. 6 BENDING STRAINS IN THIS DISK WERE MEASURED BY SCRATCH-RECORDING STRAIN GAGE

TENSOMETER

Huggenberger tensometers, their supply exhausted early in the war after imports from Switzerland ceased, also are again being supplied by The Baldwin Locomotive Works. This instrument is reported to be one of the first to so simplify strain measurement as to make it possible to measure strains in the field as well as in the laboratory. It is a self-indicating instrument, light in weight, compact, and easy to use.

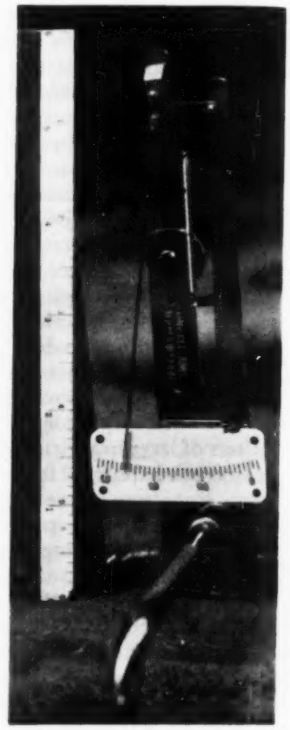


FIG. 7 TYPE B HUGGENBERGER TENSOMETER MOUNTED ON A LOCOMOTIVE DRIVING WHEEL TO DETERMINE STRAINS UNDER TEST CONDITIONS

Several types are available. One is a laboratory instrument particularly suitable for measurements requiring high accuracy and great sensitivity. Two others are made more sturdy and are suitable for use under such unfavorable conditions as adverse climate, and dusty shops, and buildings. Another is made exceptionally light in weight for use wherever lightness is important. A fifth type, also light in weight, is being used largely in studying celluloid models and in "fields of force" investigations.

All of these instruments depend on accurate lever multiplication of strains, with their magnitude indicated by means of a long vertical pointer on a scale.

Research Laboratory

ESTABLISHMENT of a new research laboratory at Case Institute of Technology was announced recently by Dean Elmer Hutchisson. The new laboratory has been named the Research Laboratory for Mechanical Metallurgy. Dr. George Sachs, member A.S.M.E., professor of physical metallurgy, has been appointed director of the laboratory.

The new laboratory is an outgrowth of the large amount of research conducted in recent years in the Department of Metallurgical Engineering at Case. During the war and the years preceding and following it, various governmental agencies, as well as private industry, established research and development projects at Case. Because of the importance of research in the instructional program, the facilities of the Department of Metallurgical Engineering were expanded to meet the growing demand. Recently, with the greatly increased undergraduate enrollment and the continuing research requirements, it was decided to enlarge the Rockefeller Metallurgical Engineering Building and establish in it the new research department. The new laboratory will supplement the graduate instructional and research facilities of the Department of Metallurgical Engineering, the members of which will continue to carry on research

and development as in the past. The modern equipment of this laboratory is said to make it one of the most complete of its type in the engineering colleges of the country.

Problems on which the laboratory group is working at present include flow and fracture of metals, analysis of various metal-forming and joining processes, stress and strain analysis, heat-treatment of steels, and metal casting. Among the government agencies for which research projects are being carried out are the Office of Naval Research of the U. S. Navy, the Army Ordnance Department, the Committee on Ship Construction of the National Research Council, and the National Advisory Committee for Aeronautics.

In addition to their use for sponsored research, the laboratory's personnel and equipment are being utilized for graduate thesis work. Under the current G. I. Bill of Rights, many veterans are taking advantage of the facilities offered by the laboratory in their work for advanced college degrees.

Fire-Protection Manual

PUBLICATION of the 1947 edition of "Approved Equipment for Industrial Fire Protection" has recently been announced by the Associated Factory Mutual Fire Insurance Companies. Greatly enlarged, the new edition lists not only the names of manufacturers and the specific devices which have been tested and approved by the Factory Mutual Laboratories, but also contains typical illustrations and engineering data and recommendations on the use of equipment. Copies have been offered free of charge to properties insured in the Factory Mutual Companies.

Optical Drill Chuck

THE drill chuck shown in Fig. 8, and described in *Engineering*, July 4, 1947, although of the orthodox type in so far as the shank, jaws, etc., are concerned, is fitted with an optical system which enables the operator to center the drill spindle exactly over the scribed crossmarks at which the hole is to be drilled. It is claimed that by using it, a competent operator can achieve consistent accuracy to within 0.002 in. of the scribed center, and obtain a high proportion of exact coincidences. Accuracy of this order is generally obtainable only with the aid of an instrument employing gage blocks or dial micrometer gages, and therefore requiring the services of a highly-skilled operator. The optical drill chuck, however, is designed to be employed as a working tool, and kept in position on the machine for everyday use. It has been introduced by Machine Shop Equipment, Limited, London, S.W. 1, England, and international patents are pending.

It is claimed that in all cases the optical drill chuck will increase the accuracy and decrease the working time of any operator, although the results will be the more impressive the greater the skill he possesses. Assuming the shank of the chuck to be properly inserted in the spindle nose, the operator moves either the spindle or the worktable until the center is approximately over the scribed crossmarks. He then looks through the hole *a*, Fig. 8, and sees a clearly defined pair of crosslines superimposed on an image of the actual crosslines scribed on the work. Then by suitable focusing movements and fine adjustments of the machine, he brings the two pairs of lines into exact coincidence at the point of intersection; the spindle axis is then exactly in line with the point marked off on the work.

Accurate drilling is then secured by repeated light approach strokes of the drill point to the work, the pressure being gradually increased at each stroke to permit the point to find its own center.

Dealing now with the optical system as shown in Fig. 8, the hole *a* in the cover is coaxial with the eyepiece *b*, which, in turn, is coaxial with the reticle *c* carrying the crosslines. Beyond the reticle is the prism *d*, which directs into the eyepiece the image of the crosslines on the work formed by the objective *e*. The magnification of the optical system is about 8×.

There are two distinct focusing movements, one for establishing the correct relationship of the eyepiece to the reticle, and the other for focusing the image of the scribed lines on the work formed by the objective. The movement of the eyepiece is for focusing the reticle crosslines to suit individual eyesight. The focusing of the image of the crosslines on the work is effected by raising or lowering either the drill spindle or the workpiece. Generally, the chuck is designed for this latter

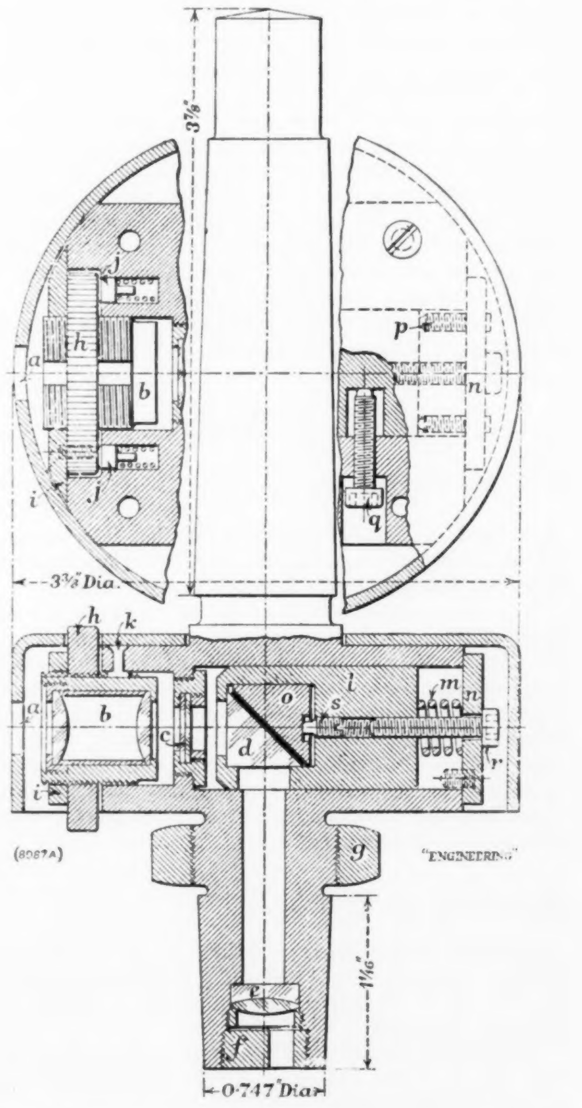


FIG. 8 DRILL CHUCK WITH OPTICAL CENTERING DEVICE

(*a*, Sighting hole; *b*, eyepiece; *c*, reticle; *d*, prism; *e*, objective; *f*, guard plug; *g*, chuck withdrawing nut; *h*, eyepiece focusing nut; *i*, bridge; *j*, spring-loaded plungers; *k*, key to hold eyepiece in place when turning nut *h*; *l*, prism-carrying block; *m*, spring; *n*, bridge piece; *o*, prism-holding block; *p*, locking screws; *q*, block adjusting screw.)

focusing at about the same height as the chuck will be when the drill is in place. The whole operation calls for no particular skill; the chuck is perfectly focused when on slightly moving the head there is no relative movement between the reticle crosslines and the image of the work crosslines.

Insulation Data

THE Industrial Mineral Wool Institute, as a service to consumers and the trade, has just published a new 24-page illustrated manual entitled "Holding Low Temperatures With Better Insulation."

The booklet, reported to be the first of its kind, covers: How to select insulation and what to look out for; data on forms, properties, and application methods; and the principles and significance of vapor-proofing for various types of wall, floor, and ceiling construction. It also contains analyses of typical case-history installations in cold-storage work, freezing processes, cold-aging, food distribution, industrial refrigeration, and air conditioning.

Graphs on representative thermal conductivities of various mineral-wool forms; a chart for computation of minimum insulation thicknesses to prevent condensation on cold surfaces in various environments; minimum thicknesses and recommended techniques for pipe insulation; data on long-term storage temperatures for various food products; and recommended procedures for the vapor-sealing of masonry, wood, block, and plastered walls may prove helpful to users.

Single copies are available free of charge from the Institute at 441 Lexington Avenue, New York 17, N. Y.

U. S. Army

Weather Forecasting

A SMALL but efficient weather station has been installed at the White Sands, N. M., Guided Missiles Proving Ground by the Air Weather Service of the Army Air Forces.

The weather station is unlike other stations in that the technicians at White Sands are primarily interested in meteorological conditions of the upper-air regions rather than weather close to the earth's surface which affect normal air traffic.

For this reason the weather technicians use the latest in radio and electronic weather-detecting equipment. Large 2000-gram neoprene balloons carry delicate instruments to about 100,000 ft with ground radio receivers, direction-finding equipment, and surveillance radar units to correlate weather conditions at extreme heights.

Supersonic Aircraft

The Army Air Forces has awarded a contract to the Douglas Aircraft Company, Santa Monica, Calif., for a design study of the third of a series of supersonic aircraft, which has been designated the XS-3.

The study is being directed toward the development of a design capable of speed three times that of sound and with an altitude ceiling of 200,000 to 300,000 ft.

So far the company has made 60 different design studies, ranging from a stubby, blunt-nosed model to a long slender fuselage that comes to a sharp bulletlike point fore and aft. Ramjet, rocket, pulsejet, and turbojet types of propulsive units, both singly and in combination, have been studied as possibilities.

Guided Missile Instrumentation

In co-operation with the U. S. Navy, the Army Corps of Engineers will install instrumentation capable of showing the speed, trajectory, range, and other characteristics of guided missiles for approximately the full 90-mile length of the White Sands Proving Grounds in New Mexico. This instrumentation system, which has been started with funds provided by the Navy, will be co-ordinated with existing and proposed Army installations in order to properly orient and integrate all communication and instrumentation facilities at the Proving Grounds.

The construction program calls for the erection of approximately 75 additional instrumentation stations and access roads. The stations will be of semipermanent construction, dust-proofed as necessary to house doppler and radar equipment, tracking cameras, cine-theodolites, and other paraphernalia.

Radar Weatherman

The introduction during the last war of the long-range bomber and various types of guided missiles has increased the responsibilities of weather officers of the Army Air Forces to a point where ordinary weather forecasting has become an exacting science requiring skilled technicians with specialized schooling.

The Air Weather Service and the Air Training Command, looking ahead to the time when knowledge of atmospheric behavior may have an even greater effect on aerial defense, have established weather schools for A.A.F. personnel employing the newest war-born devices for the detection, plotting, and forecasting of weather.

The increasing use of ground and air-borne radar as an electronic weather-detecting and reporting device has created a new type of weather technician, the radar weather officer. One of the most highly skilled technicians, the radar weather officer must be both a qualified meteorologist and a radar expert. An officer selected for this type of assignment must receive a full year's training at the A.A.F.'s radar school, as well as completing the prescribed weather officer's course.

B-50 Superfortress

Cruising 27 per cent faster than the B-29 Superfortress and approximately 50 mph faster than any other Army bomber capable of equal range, the latest addition to the Army Air Forces postwar aerial fleet, the Boeing B-50, made its first test flight recently at Boeing Field, Seattle, Wash.

Although externally it greatly resembles the B-29, 75 per cent of the B-50's design is new.

Powered by four 3500-hp Pratt & Whitney Wasp Major engines, the B-50 will be capable of a top speed approaching 400 mph and a maximum range greater than that of the B-29.

Arctic Troop Shelter

A prefabricated temporary Arctic shelter for troops, capable of providing an interior temperature of 70 F while the outside thermometer registers 70 deg below zero, and also capable of withstanding the impact of a 125-mph wind, is being designed by the Corps of Engineers. Present plans call for a building light enough in weight to be transported by airplane or glider and so simple in construction that it can be erected quickly by unskilled men wearing Arctic clothing, including gloves.

Construction also must be of a character that will permit

removal and quick reassemblage; must be in units that will permit various sizes of buildings, from personnel housing to administration buildings; and the housing must be adaptable to warehousing, either hot or cold storage, shops, post exchanges, hospitals, mess halls, and such other buildings as are necessary in the operation of an Army post. The buildings must be of a character to be fitted to any terrain.

Speed Record

An Army Air Forces Lockheed P-80R jet-propelled "Shooting Star" flashed across a three-kilometer course at Muroc Army Base, Calif., June 19, 1947, at 623.8 mph to recapture the world's speed record for the United States for the first time in 24 years. The previous record of 616 mph was held a little more than nine months by Great Britain.

The P-80R was powered with an Allison Model 400 turbojet engine. This is a new model of the General Electric J-33 jet engine which has a greater compressor capacity and employs water-alcohol injection.

This engine is said to be the highest-powered jet engine ever manufactured in this country, having a top thrust rating of more than 4600 lb. Specifications for the Model 400 are: Take-off power (dry), 4600 lb static thrust; military power, 4600 lb static thrust; maximum continuous power, 3600 lb static thrust; military power S.F.C., 1.13 lb per lb thrust per hr; maximum continuous power S.F.C., 1.12 lb per lb thrust per hr; cruise S.F.C., 1.14 lb per lb thrust per hr; engine weight, 1735 lb.

Communication Device

The Optiphone, an ingenious device which permits telephone communication over a narrow beam of white or dark red light, was displayed to the public for the first time at a recent Signal Corps exhibit at Atlantic City, N. J.

The equipment, developed by the Signal Corps Engineering Laboratories, Bradley Beach, N. J., was used successfully toward the end of the war by General Patton's Third Army. It was designated as telephone-link equipment or for point-to-point communication where laying of wire lines was impossible or impractical and where radio silence was necessary.

The Optiphone provides single-channel, two-way, break-in speech communication and consists of an optical unit, a control unit, a storage battery, and a field telephone. The complete unit weighs 145 lb. Optical range is up to four miles during daylight and up to seven miles at night with dark red filter, depending on atmospheric conditions. The field telephone is used directly with the equipment for point-to-point communication.

Climatic Hangar

The Army Air Forces' climatic hangar at Eglin Field, Fla., headquarters of Air Proving Ground Command, is now in operation.

The hangar, which can simulate extreme weather conditions, was developed to meet A.A.F. needs for a central testing site where new aircraft and equipment could be subjected to climatic conditions which might actually be encountered in operational flying. Before the hangar was developed, such test work was accomplished in natural locations which presented many problems, chief of which was the distance which the equipment had to be transported and the time lost in waiting for proper temperature conditions.

The climatic-hangar unit consists of a main insulated hangar, 200 × 250 ft, with ceiling heights varying from 35 ft at the sides to 70 ft at the center; an equipment and engine test room 30 × 113 ft, and 25 ft high; a cold test room, hot test room, desert test room, jungle test room, and tropic-marine test room, each approximately 13 ft square; a 13 × 34-ft all-weather room for physiological testing; and a refrigerated strato-chamber, 10 × 14 ft. In addition, provisions have been made for simulated wind storms of velocities up to 100 mph, in combination with sleet, snow, rain, and sand.

Helicopter

The Army Air Forces' largest helicopter, the Kellett XR-10, has successfully completed its first test flight at Kellett's North Wales (Pennsylvania) plant.

The first twin-engine transport-type helicopter in the world, the XR-10 was designed to service ground-force units in ordinarily inaccessible areas. Powered by two Continental 525-hp engines, the XR-10 is the world's most powerful helicopter. It has two counter-rotating, intermeshing, three-bladed rotors, both of which can be driven by either of the two engines. The counter-rotating rotors counteract the normal tendency of a plane to twist in the direction of blade rotation, thereby eliminating the need for the customary tail rotor. Rotor diameter is 65 ft, the largest ever built.

Capable of carrying 10 passengers in addition to the pilot and co-pilot, the XR-10 is the world's heaviest helicopter, having a gross weight of almost 11,000 lb. In an emergency, six wounded personnel on litters could be carried. A cargo load of 2000 lb can be carried in lieu of passengers.

The XR-10 has a maximum speed of more than 100 mph and, at a cruising speed of 90 mph, it has a range of almost 350 miles.

An innovation in the construction of the new helicopter is a hatch opening in the fuselage, 33 in. wide and 52 in. long, equipped with a hoist and harness for picking up or lowering personnel or cargo from a hovering position.

Underground Pipe Storage

A PILOT installation using pressure vessels fabricated from lengths of seamless steel pipe for storing 1,250,000 cu ft of natural gas at 2240 psi has recently been placed in service by the Public Service Company of Illinois near Kankakee, Ill. It is intended to supplement low-pressure distribution in the Kankakee area and provide an emergency supply for high-pressure customers in the area normally supplied from the high-pressure distribution feeder main from Mattison, Ill. Another unit capable of storing 40,000,000 cu ft is now in process of construction at Evanston, Ill.

The basic design was developed by the Public Service Company of Illinois, Stone and Webster, and National Tube Company. This pipe, of alloy steel having a yield point in excess of 80,000 psi, is furnished in 40-ft lengths, 24 in. O.D., and 0.512 in. wall thickness. Each end is hot-swaged to contour in five stages using a 2000-lb steam hammer. One end is then cut to length and rough-bored, after which the cylinder is normalized to produce the desired grain structure in the steel. Following this operation the cylinder is shot-blasted and both necks finished to the required size in a special horizontal boring mill. The cylinders are then subjected to a 2800-psi hydrostatic test in a water jacket to determine that the permanent set at this pressure does not exceed prescribed limitations, following which they are prepared to receive a mastic coating and the ends plugged for shipping.

Forty lengths of pipe, fabricated into storage cylinders, arranged in five lines of eight units, four on each side of a manifold, were used in the Kankakee installation. Each unit, on an average, has an internal volume of 109.66 cu ft and is capable of storing approximately 30,000 cu ft of natural gas. Of particular interest to companies using these storage units is the compressibility factor of natural gas, which shows maximum deviation from the laws of perfect gases near the pressure of 2240 psi at which the gas is stored. Whereas approximately 160 cu ft of a perfect gas could be stored in 1 cu ft of space at 2240 psi pressure and 40 F, it is possible to store approximately 230 cu ft of natural gas under the same conditions. Standard spacing for the tubular storage units is 8 ft end to end and 15 ft between center lines. All piping is coated and provided with cathodic protection. Earth cover of 3 ft 6 in. is said to be sufficient to minimize seasonal temperature changes.

Should failure of a single pipe occur, it will not affect adjacent units and further, a unit may be taken out of service for inspection or repair without disturbing the remainder. Being underground, no aviation hazards are involved, nor are the storage units affected by storms or rapidly fluctuating temperature conditions.

Passenger Cars

THE Central of Georgia Railway accepted delivery in July, 1947, from the American Car and Foundry Company of ten streamlined cars which are considered outstanding examples of modern passenger-car design and construction. Part of this new equipment, consisting of one de luxe compartment coach, one de luxe partition coach, one de luxe grill-lounge car, and one coach-baggage car, will operate as a four-car train on the run between Savannah and Atlanta.

The streamlined train is said to represent the ultimate in modern and practical transportation at coach rates. Such innovations as appear on this train—the new "Dayflector" lighting system, the vanity lounge for women passengers, and the unique arrangement of the grill-lounge car—are the outcome of surveys of the traveling public's requirements.

The lighting arrangement in the coaches is entirely new. Dayflector vanes, placed between the glass in the upper portions of the windows, serve to project the daylight upward toward the basket baggage racks which have solid undersides forming a reflection area. Striking the baggage rack and ceiling of the car, the daylight becomes diffused in a soft even glow. At night, tubular fluorescent lighting accomplishes the same restful diffusion by means of a reflection system.

Of particular interest is the large amount of space devoted to air-conditioned washrooms and the ultramodern facilities with which these will be equipped. The women's washrooms in the day coaches will contain three combination vanity-and-washbasin fixtures arranged in a semicircle and providing ample elbow room.

In the compartment coaches a partition divides the coach which has washrooms and toilets at each end for both men and women. The seating capacity of the compartment coach is 68–40 in one compartment and 28 in the other.

The grill-lounge car is equipped with a lunch counter seating six passengers for light meals or "snacks" as well as a more conventional dining section accommodating 16 persons. A lounge section with built-in settees provides a seating capacity for 24 travelers.

All cars embody the same basic underframe and side construction and are designed to meet fully the requirements of the U. S. Railway Post Office specifications and the A.A.R. specifications covering the construction of new passenger equipment. All material used in the framing is low-alloy high-tensile steel, with the exception of the center sills and vertical end members which are of open-hearth steel having a minimum yield value of 36,000 psi.

The coaches and cafe-coach are insulated with Fiberglas insulation and the divided coaches and passenger car with Stonefelt; sides and roof of all cars have 3 in. thickness of insulation, while ends and floors of all cars have 2 in. thickness.

Four-wheel single-drop equalizer trucks are used under all cars, with $5^1/_2 \times 10$-in. journals equipped with Hyatt roller bearings with smoke bombs to indicate overheating of bearing. Both equalizer and bolster springs are of helical-coil design of alloy steel. Vertical motion is controlled by Monroe shock absorbers and the truck bolsters are restrained by rubber-cushioned bolster anchors.

Sound-deadening materials, Fabreeka and rubber, are used to isolate noises completely from the car body, principally at bolster springs, truck center plates, and body side bearings; also at moving parts of coupler and buffer mechanism.

Heat Pump

THE heat pump used for heating all the offices and shops of Brown Boveri & Company, Limited, Baden, Switzerland, is described by P. Real in *The Brown Boveri Review*, October, 1946. This heat pump enables 3300 kilocalories (kcal) to be obtained from each kwhr used for the purpose of heating, instead of only 860 kcal, which would be obtained by direct conversion of electricity into heat, as, for example, in an electrically heated boiler. This seemingly impossible heating efficiency is achieved by drawing heat from a low-grade source, in this case the water from the River Limmat, and transferring it to the heating system.

Fig. 10 illustrates the heat cycle employing a heat carrier as the medium of heat transfer; it also indicates the temperatures corresponding to the cycle. Inside the evaporator are tubes

FIG. 9 DIAGRAM OF COACH SEATING 56 PASSENGERS

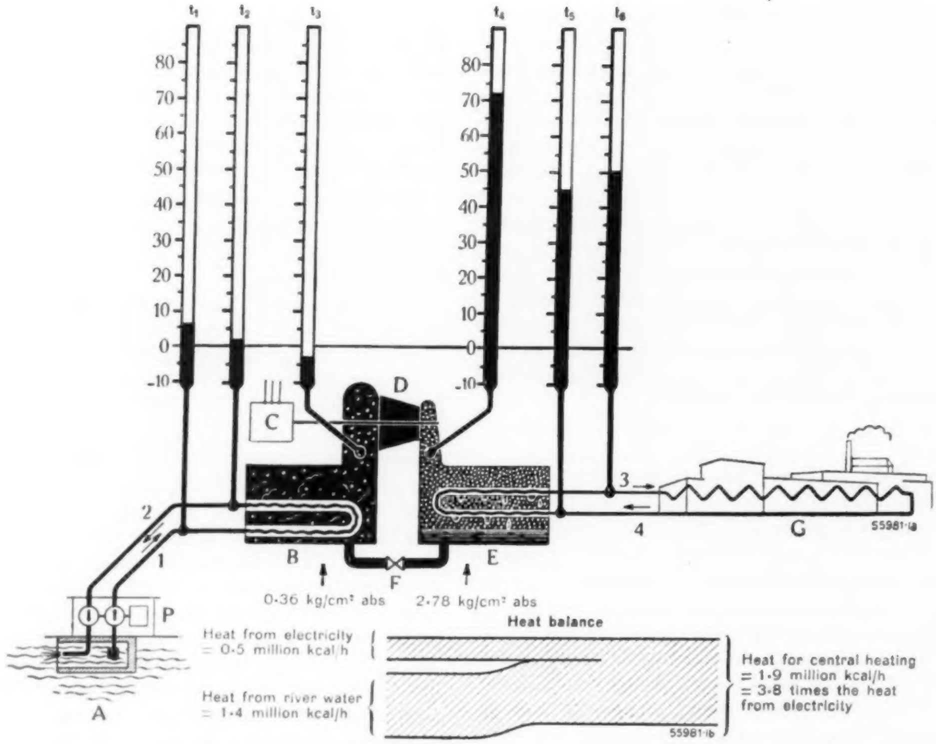


FIG. 10 DIAGRAM SHOWING THE TEMPERATURES AT VARIOUS POINTS ON THE HEAT PUMP

(A, source of heat, for example, river with pumping station P; B, evaporator; C, motor for compressor; D, compressor; E, condenser; F, regulating valve; G, central heating system; 1, 2, river-water circuit; and 3, 4, hot-water circuit. Thermometers t_1—t_6 indicate the temperature during the heating period and the heat balance illustrates the corresponding quantities of heat.)

through which the river water serving as a heat source flows. On the outside of the tubes is the liquid heat carrier, which consists of Freon 11 (monofluor-trichlormethane, $CFCl_3$). The pressure of the Freon in the evaporator is kept sufficiently low to evaporate at a temperature below that of the river water, to permit the heat in the water to be transferred to the heat carrier for its evaporation. The heat taken out of the water and pumped through the evaporator can be fully recovered from the evaporated Freon. This vapor passes into the compressor where it is compressed. It is then forced into the condenser, in which are tubes through which the heating water flows. The increase in pressure by a few atmospheres is so chosen that the Freon vapor condenses at a temperature which is above that required for the heating water. Thus it is possible to transfer the heat of evaporation and compression of the Freon vapor to the hot water.

The heat balance, Fig. 10, bottom right, illustrates that of the total of 1.9 million kcal supplied hourly to the heating water, 1.4 million kcal are taken out of the river water, and that only 0.5 million kcal has to be supplied as electric energy to the compressor. By means of a regulating valve, the Freon condensate then expands, that is, it passes from the condenser to the evaporator. Owing to the expansion process it arrives in the evaporator at a very low temperature. The cycle is now repeated.

In order to explain the principle more clearly, it may be said that there is no fundamental difference between the heating machine just described and a refrigerator. For example, in every domestic refrigerator the heat taken out of the food and that which is supplied in the form of electric energy is utilized for the purpose of heating the kitchen or the office, which is purely unintentional; the purpose of this type of heat pump is, however, cooling. The heat pump under consideration is employed for the opposite purpose, namely, not for the cooling of the river water, but for the heating of central heating water, which alone is of any practical importance.

Flying Laboratory

THE famous Flying Laboratory, "Old '71," of the Sperry Gyroscope Company, Inc., Great Neck, N. Y., has been loaned to The University of Southern California College of Aeronautics in Santa Maria for aeronautical experimentation and research.

For seven years the specially-built Lockheed Hudson carried on extensive tests for Sperry, the armed forces, and manufacturers. When she has served her purpose at U.S.C. she will be retired to a berth already reserved among the "firsts" in aviation in the National Aeronautical Museum recently provided for by the Congress.

Dr. Maurice Nelles, member A.S.M.E., head of Aeronautical Engineering for the college, said that it will be used for educational and research activities, primarily as a flight laboratory for senior aeronautical-engineering students. He said it will be instrumented with scientific equipment enabling students to conduct research in aircraft design and safety. Measurement of structural behavior in flight will be made with the aid of electric-strain-gage recorders and impact-load measuring devices.

The airplane also will be equipped to measure control-system forces and pressures under various load factors. Air-conditioner and hydraulic-system performance will be measured. The electric equipment will include microwave, ultrahigh-fre-

quency and frequency-modulation radio equipment instrumented for educational purposes.

Engines of the airplane are equipped with torquemeters, temperature- and pressure-measuring devices, and special equipment for making detonation studies. The airplane is specially equipped with aerial cameras to which recording cameras will be added. The plane also will be used in the junior course in photogrammetry.

Air, sea, and ground research on frequency modulation in the ultrahigh frequencies is contemplated as a co-ordinated project between the College of Aeronautics and the FM Station KUSC of the Allan Hancock Foundation on the main campus of U.S.C. in Los Angeles and the floating scientific laboratory Velero IV, now under construction in San Diego. It is planned to carry on research and development projects for governmental agencies as well as for educational purposes.

Metal Cutting

THE laboratory for the investigation of metal cutting at the Gorki Automobile Works in Russia has now concluded its experimental investigation into the cutting of hard metal, such as carbides, by means of the electroerosion process, according to a review in *The Engineering Digest*, July, 1947, of an article by T. P. Rekshinskaya, published in *Automobilnaya Promishlenost*, No. 5/6, 1946. The original Russian report, referred to in the January, 1947, issue of MECHANICAL ENGINEERING, pages 30 and 31, described the cutting action as an electrolytic process, while it is now known as a spark-discharge process. It is defined as the destruction of a metal surface by means of an electric spark discharge between the poles of a direct-current circuit. The spark discharge is produced by breaking the current between the poles, and this is accompanied by the removal of particles from the anode surface and their carry-over to the cathode using an electrolytic fluid as a medium.

From the machine itself, Fig. 11, it is seen that in the lower part of the welded frame a reservoir for the cutting fluid is provided from which the fluid is conveyed to the surface of the piece to be cut. Above the worktable of the machine a counterweighted swinging bracket is arranged to carry a cutting disk. The axle of this disk and the vise which grips the workpiece are both connected to a direct-current circuit, the disk being connected with the negative terminal, and the vise with the positive terminal. The circuit is closed by lowering the disks upon the workpiece. The counterweight of the swinging bracket is so dimensioned and so positioned, that the cutting disk rests on the workpiece. With slight pressure this gives rise to an electric discharge which produces electroerosion. The spindle of the disk is driven at the speed of 750 rpm by a 2.5-kw motor, the latter running at 1500 rpm. The pump handling the cutting fluid is equipped with separate drive.

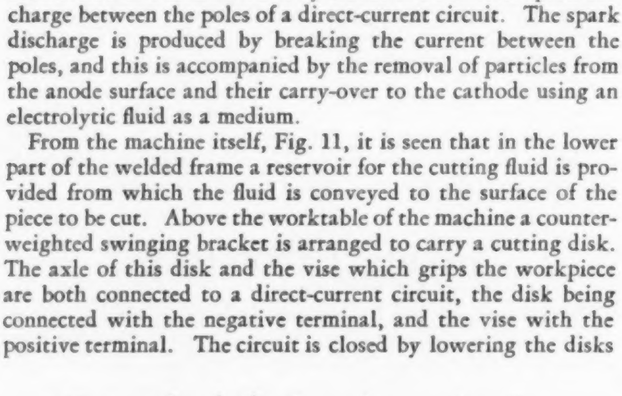


FIG. 11 DIAGRAM OF ELECTROEROSION CUTTING MACHINE

(1, machine bed; 2, pump; 3, tank; 4, vise; 5, cutting disk; 6, disk spindle; 7, disk support arm; 8, electric motor; 9, counterbalance level; 10, counterbalance weight; 11, negative contact; 12, positive contact)

The density of the cutting fluid, which is an important factor, is checked by means of a hydrometer. The cutting disk is made of mild carbon steel and is of 0.5 to 2.5 mm thickness and of 150 to 350 mm diameter.

The relationship between cutting and disk diameter is charted in Fig. 12. These data refer to the cutting of 26 × 13-mm sections of a high-speed tool RF-1, containing 0.7 to 0.8 per cent carbon, 3.8 to 4.6 per cent chromium, 17.5 to 19.0 per cent tungsten, and 1.0 to 1.4 per cent vanadium.

The results of tests conducted to ascertain the relationship between cutting time and disk speed show that the cutting time sharply decreases with decreasing disk speed. The influence of the thickness of the disk upon cutting time indicates that the cutting time becomes shorter with decreasing disk thickness. The minimum thickness that can be employed is governed by concentrations of mechanical strength and the most suitable thickness has been found to be 0.5 mm. In the tests the contact pressure of the disk feeding into the cut did not exceed 2.5 kg; variations in contact pressure were found to have little influence upon cutting time. The density of the electrolyte has considerable influence upon the cutting process; a density between 1.32 and 1.34 Baumé is recommended. Although various liquids have been tried for the electrolyte, only waterglass gave satisfactory results.

Performance figures obtained with the electroerosion method of cutting metals are given in Table 2.

TABLE 2 METAL CUT BY ELECTROEROSION PROCESS

Type of steel	Condition of steel	Section, mm	Time for one cut, min	Diametral wear of disk per cut, mm
RF-I	As supplied hardened	26 × 13	0.65	0.5
RF-I		26 × 13	0.65	0.5
Kennametal KM		26 × 13	3.15	3.4
Fermite T-16		32 × 20	8.5	3.17
RE-8		18 × 10	2.5	3.25
RE-8		26 × 13	3.25	3.6
40 Kh	As received	20	1.15	0.45
40 Kh	" "	40	2.9	1.75
40 Kh	" "	80	12.1	6.2
35 KhGSA	" "	20	1.15	0.9
35 KhGSA	" "	40	2.8	1.8
35 KhGSA	" "	80	10.5	5.93

Cutting time and disk wear increase rapidly as the area of the section cut is increased.

It is concluded that electroerosion cutting of hard metals or steel should be carried out with a copperplated disk made of mild carbon steel, having a diameter between 150 and 350 mm, but preferably not exceeding 170 mm. The disk should be 0.5 to 0.8 mm thick, and the copper layer 0.016 mm. The peripheral speed of the cutting edge should be between 6 and 10 meters per sec. The cutting pressure should be between 0 and 1.5 kg per cm². The diameter of sections cut should not exceed 85 mm. The recommended voltage is 18 volts, resulting in a current of 80 to 100 amp. Careful guarding is necessary to prevent splashing of waterglass.

It is reported that a comparison between the new method and three conventional types of cutting—bandsaw, power hack saw, and Heller saw—indicates that only electro-cutting is suitable for hard metal. It is said to give smooth surfaces, with sharp

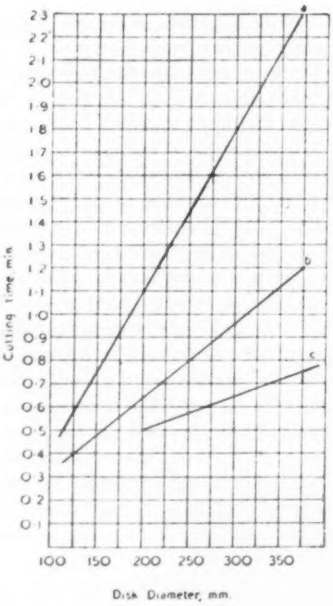


FIG. 12 INFLUENCE OF DISK DIAMETER UPON CUTTING TIME

[Thickness of disk 0.5 mm; pressure of disk upon workpiece 1 kg; density of electrolyte 1.32 deg Bé; power consumption 935 watt. (*a*) Disk speed 2850 rpm; (*b*) disk speed 1450 rpm; (*c*) disk speed 750 rpm.]

and even edges. Warping of the butt end does not exceed 0.5 mm. The loss of hard metal by cutting is low, as the width of the cut does not exceed 0.85 mm. This makes it possible to cut off slices of 2 mm thickness which is impossible with any other cutting method. Cutting by electroerosion supersedes the employment of abrasive disks for the cutting of hardened workpieces. It is quicker and does not cause overheating and loss of hardness of the sections affected. In the cutting of bar stock not exceeding 12 sq cm in area the output by the electroerosion method is greater than that of power hack saws, but the process is somewhat more expensive.

The electroerosion process is recommended for the cutting of: (1) All types of hard metal of any sections used at present in the motor industry; (2) hardened steels and other very hard metals provided the sectional area does not exceed 16 sq cm; and (3) bar stock of steel and other metals provided the sectional area is not in excess of 5 sq cm. In case (2) the electroerosion method takes place of abrasive cutting, and in case (3) that of cutting with the power hack saw.

Waste-Wood Utilization

CONVERSION of waste wood into steam power, making it unnecessary to purchase electricity from outside sources, has been realized by the United States Plywood Corporation, Algoma, Wis. The "heart" of the recently completed power plant is a 750-kw turbine generator.

Steam power is supplied by three 500-hp water-tube, water-wall boilers, with operating pressure of 200 psi. The three boilers will carry the extreme peak load of the plant which is anticipated for only a few months of the year. This will allow repairs on any one of the boilers at any time except during this extreme peak.

Each boiler has a Dutch-oven-type furnace that efficiently burns "hog fuel," which is wet and dry lumber and veneer waste wood reduced to chips by special knife and hammer-type machines. The wood waste is conveyed on a continuous system through the "hogs" and directly into the Dutch-oven furnaces.

Planer shavings and sawdust are picked up from the production machines throughout the plant by a network of suction pipes and blowers which pneumatically convey the material to the large cyclone-type separators on top of the power-plant building. The purpose of the separator is to allow the air of the system to discharge to the atmosphere and the solid wood fuel to drop by centrifugal force and gravity to the furnace.

A unique system of handling and burning the sander dust is in use to reduce the explosion hazard that accompanies the handling, storage, and burning of this fine dust. The dust is stored in suspension in a separate cyclone-type separator and relay fan system. A portion of the duct through which this suspended dust passes is equipped with an electronic eye so that when the mixture reaches the right density it automatically switches a valve that discharges the combustible material through a special dust burner which acts like a blowtorch in the combustion chamber of the furnace.

When the concentration is reduced as the fuel is used up, the electronic eye activates the valve, causing the mixture to again circulate until the density is built up to the required amount for safe and efficient combustion.

Fuel-oil burners are on each boiler to furnish auxiliary energy for peak loads if there is not enough waste-wood fuel.

Each boiler has a 182-ft-high stack to produce adequate natural draft required to burn wet waste wood.

In case of an emergency, electricity is available from a near-by municipal plant. A switchboard is arranged so power can be synchronized with the municipal power either for divided load, for all municipal power if the need should arise, or for all the power generated by the mill itself.

Hot-Cold Pipe

ACCORDING to an article in the July, 1947, issue of *Westinghouse Engineer*, scientists currently are interested in the performance of a narrow piece of pipe that receives a blast of compressed air through a nozzle at its center and neatly divides it into two jets; one as hot as 154 F, the other as cold as 10 F. Aside from its practical application—at the moment not too promising—the tube produces a startling thermodynamic effect that physicists are eager to explore and understand.

Called the "Hilsch tube," after a German scientist who did experimental work on it, the device recently was brought to America for further study. G. W. Penney of the Westinghouse Research Laboratories has built a revised version of the tube for fundamental research into the thermodynamic principles involved. His model—made several times larger in diameter for easier study—consists of a 15-in. length of brass pipe about 1 in. in diameter. Compressed air up to 50 or 60 lb is pumped into a nozzle at the one end of the tube to produce a vortex of rapidly spinning gases.

The cooler air concentrated in the center of the whirlpool is drawn out through an opening in the middle of the tube, or at either end if desired. The warm air is driven out through an opening near the walls of the cylinder. Thermocouples inserted in the air stream measure the temperature differences. Because he is more interested in understanding the nature of this separation of heat from cold, Penney's model is not constructed to produce the wide temperature variations observed in the original.

What really happens is not clear. One theory deduces that the various layers of whirling gas have different velocities, rising from virtually zero at the center of the vortex to a peak at some intermediate point and then falling away at the periphery. This may cause the gases of high velocity to exert a frictional or "shear" effect on those of lower velocity, thus transmitting energy to the latter. The net effect is, then, a considerable warming of the outer layers of gas and a corresponding cooling of the inner layers. The law of conservation is binding here.

Whatever heat is extracted to produce the cold stream of air must be added to the warmer end of the flow.

A natural application of this ultrasimple device would seem to lie in the field of refrigeration. But its efficiency is only a small fraction of that attained in household refrigerators and large cooling units. However, it may be useful as a laboratory tool.

Image-Orthicon Camera

A NEWLY designed image-orthicon camera has been announced recently by Allen B. Du Mont Laboratories, Inc., Passaic, N. J. The new camera is said to include features never before incorporated in television cameras.

All essential controls are concentrated at the rear of the camera making it easier to operate. Hinged and removable panels permit immediate adjustments and replacements in the field or in the studio with minimum loss of time.

Employing a supersensitive image-orthicon pickup tube, the camera features a lens turret that takes up to four lenses of various focal lengths. The turret is operated by a rotatable handle at the rear of the camera, locking any one of the indicated lenses in position. Diaphragm setting and focusing are also controlled from the rear of the camera.

To avoid parallax difficulties, the camera retains the Du Mont-originated electronic view finder. Mounted on top of the camera proper, this assembly slips down in place, at the same time establishing plug-in connections. The electronic view finder chassis is included in the camera housing. The televised image as shown on the view finder screen is viewed through the shadow box at the rear of the camera. The camera can be operated with or without the electronic view finder, an optical view finder being provided when necessary.

Voltage control is provided for a wide variation in pickup tubes. There are knob adjustments for all internal controls. The video preamplifier is essentially nonmicrophonic so that image pickup is virtually unaffected by vibration or jarring of the camera in operation. Tubes and sockets are arranged for immediate and convenient accessibility. Controls at the rear of the camera, made available by opening panel doors, regulate the heater or the blower for the operation of the image-orthicon tube at the proper temperature; centering of the electronic image; adjustment of the preamplifier gain and alignment coil current.

A pilot light flashes at the rear of the camera when it is "On the air." If the cameraman is following the pickup through the electronic view finder, a second pilot light flashes inside the shadow box for the cue.

Oxygen Plant

THE research and development program for the gasification and liquefaction of bituminous coal undertaken by the Pittsburgh Consolidation Coal Company, Pittsburgh, Pa., will include an oxygen plant as a part of the pilot plant to produce synthetic gas, according to an article in the April-June, 1947, issue of *Bituminous Coal Research*. (See "Oxygen," pages 762 and 763.)

Construction of the synthesis-gas plant is the first phase of the program to develop an economical method for converting coal to liquid and gaseous fuel by the Fischer-Tropsch method. In the pilot plant, finely ground coal will be converted to carbon monoxide and hydrogen using steam and oxygen. It is estimated that the pilot plant to produce these "building block" gases will cost approximately $500,000.

Designs for the plant are being completed and construction will require about one year. The plant is designed so that entire units can be replaced or rebuilt if such modifications prove to be necessary. It is expected that optimum operating conditions including reaction time, temperature, and pressure, as well as dimensions of reaction vessels and other operating information, will be revealed in the pilot operation.

The second phase of the program, conversion of the synthesis gas to liquid hydrocarbons, is well advanced as a result of developments by the oil industry, particularly the pilot-planting of the process by Standard Oil Company (New Jersey) at Baton Rouge, La., where gasoline and liquid fuels are produced from natural gas. As a result of these developments commercial plants are to be built in Brownsville, Texas, and one in Kansas, for the production of gasoline from natural gas. It is believed that by the time Pittsburgh Consolidation is ready for the first phase of the process, that is, gasification, the oil industry will have perfected the synthesis phase and the two will be ready for linking into a commercial coal refinery.

Today's Pattern of Industrial Relations

(*Continued from page 753*)

and the tendency of management to be unduly arbitrary, capricious, negligent, impersonal, and too little concerned or guided by the interests of workers. The tragedy of the matter is that unions are an inept, poorly designed, and even obstructive agency respecting most of these problems. Nevertheless so long as these problems are not brought under more effective control by management, and by management and Government working co-operatively, there will not be sustained popular support for any drastic curbs on unions.

At the present time unions are engaged in four different but more or less related lines of action—economic price-making actions; political action; mutual-aid services; and what might be called industrial democracy, that is, the development of rules and procedures to present and administer matters of working relations between the workers and management. Granted an effective labor market, unions would have no place in wage administration beyond the handling of grievances. Political action by pressure groups has no place in a democracy; Government should be concerned only with the public common interest, not with special interests. Insurance or mutual aid is better handled as a government function. This leaves for unions the handling of what I have called industrial-democracy problems. For this I think workers need an organization and a measure of coercive power. Managements do tend to be arbitrary, inconsiderate, negligent, and mistaken. Theirs is the responsibility to manage, but management should be subject to effective challenge. Workers need unions with sufficient power, if necessary, to force management to listen and to give full and fair consideration to their presentations. More power than this in the hands of unions is excessive. This goal would be achieved, in my judgment, if unions with some exceptions were limited to organizing and bargaining on a single operating company basis. We should abolish forthwith the great national unions and industry-wide bargaining.

What is the outlook for labor relations—continued trouble and progressive degradation and undermining of our free society? It will be so unless we proceed promptly and effectively to develop a program of action along the lines outlined. The present pattern of company action in industrial relations is good as far as it goes, but it reaches issues of only secondary importance.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Utilizing Waste Wood

To the Editor:

A recent paper by J. A. DeLuca[1] inspired the writer to submit one man's approach to the problem of utilizing what is usually considered to be waste wood.

Owing to the recent lumber shortage, an effort was made to utilize packing crates, boxes, and discarded building lumber to construct the desk, cabinet, and bookcases shown in Figs. 1 and 2 of this communication. While taking an orange crate apart, a patented method[2] was discovered for joining together short ends of boards. The feature of the patent is a modified tongue and groove with the approximate dimensions given in Fig. 3. The built-up board had the dimensions given in Fig. 4.

Since this method of joining short ends of lumber was used to manufacture a lowly orange crate, it probably is an economical means of conserving material.

The cabinet and bookcases, shown in Figs. 1 and 2, as noted, were made entirely from scrap lumber and produce crates. The desk, drawers, and book cases were made from an old roll-top desk and table leaves.

The scrap lumber was covered with dirt; some of the boards had been used for concrete forms, and the concrete still adhered to them. As much dirt and concrete as possible was removed with a wire brush and a scraper, the balance being removed at the expense of a hand-plane blade. The wider boards were used for frames. Paneling was made by gluing together strips from vegetable crates. Some of the frame pieces were badly bowed after having been dressed, but when assembled into the completed structure, they pulled into shape nicely. When completely assembled, the structure was stained a red mahogony, and coated with varnish. The final appearance is rather pleasing.

As a brief discussion of Mr. DeLuca's paper,[1] it is noted that a wide range of boxes and crates, which probably could not be covered by any classification in the paper, has been overlooked. This group includes boxes and crates for fruit and produce. Since most of these products are shipped in a highly humid atmosphere, and sometimes even shipped completely surrounded by crushed ice, special considerations should have been given to the moisture content of wood for these boxes and crates.

FIG. 1

FIG. 2

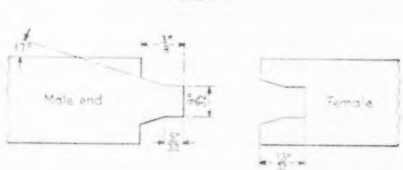


FIG. 3

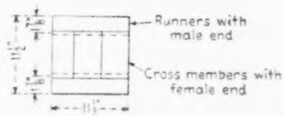


FIG. 4

Another point missed is to describe nails by means of penny number only. Some information should have been given as to the diameter of the nail. The writer has removed quite a few nails from crates during the past year and most of them had smaller diameters than the gage number listed for box nails.[3]

Audel[4] gives an interesting discussion and illustrations of a great many kinds of nails, but also lists a number of wire nails which do not conform to the penny system.[5]

The paper does not give any information as to the relative weights of the various woods. This is also important in addition to moisture content in reducing freight rates. The following item quoted from the Baltimore *Evening Sun* of April 15, 1947, shows the interest being taken with regard to weight of crates:

"Balsa wood, similar to that used to construct model airplanes, is now being adapted to crates for air-freight shipments."

As a whole the DeLuca paper contains excellent data and could well be included in a textbook for use in a general course in "industrial organization" or "industrial engineering."

Adolph M. Spamer.[6]

Author's Closure

The author was pleased to receive Mr.

[1] "The Application of Wood and Fiber to Industrial Packing," by J. A. DeLuca, Trans. A.S.M.E., vol. 69, February, 1947, pp. 163–175.

[2] U. S. Patent no. 1928547.

[3] Machinery Handbook, eleventh edition, Industrial Press, New York, N. Y., 1941, p. 1251.

[4] "Audel's Carpenters and Builders Guide," Theo. Audel & Company, New York, N. Y., vol. 1, 1946.

[5] Ibid., p. 47.

[6] Baltimore, Md.

A. M. Spamer's comments on his recent paper.[1] Mr. Spamer is to be congratulated upon being one of so few people observed these days making economic use of material which is too often regarded as waste. His energy and initiative in making up the cabinets described is to be admired. Certain criticisms of the paper are made relative to the following:

1 The water content of woods used in produce shipments.

2 The relative weights of various woods.

3 The description of nail sizes by penny numbers only.

In answer to these the author's sole defense in having omitted further elaboration is to reiterate what was made clear in the paper, that is, the paper had to be short and did not attempt to give the requirements for any one specialized field.

The author has received several requests for the paper since its publication, among them the Kollmorgan Optical Corporation, Brooklyn, N. Y., and the Department of Reconstruction and Supply, Montreal, Canada. These, as well as Mr. Spamer's generous closing remarks, give the author much satisfaction for having prepared the paper.

J. A. DeLuca.[7]

Or His Bootstraps?

To the Editor:

I read with great interest the informative and well-written article, "The Liquid-Propellant Rocket Motor" by Mr. J. H. Wyld in your June issue.

After reading this article with its prophecies of the incredible things that will be accomplished, the man using a block and tackle, on your cover picture, struck me as a perfect example of an antithesis to these predicted scientific achievements.

Perhaps the accidental coupling of this primitive lifting device with "out of this world" technical information, is an omen that if man so wills himself to "live like a baboon," one of the first devices he will probably use to pull himself out of the abyss with, will be a block and tackle.

John MacClarence.[8]

Rocket Motors

Comment by Robertson Youngquist[9]

The author has well brought out the important role which design stratagems (as against materials) have played in the evolution of durable rocket motors.[10] The rocket engineer, confronted from the beginning by the hard fact that he must deal with temperatures, velocities, and heat-transfer rates far beyond existing boundaries of experience, recognized that the problems could not be solved by the "brute-force" method, so to speak, of employing special materials. That the design approach has been fruitful is shown by the fact that the A-4 motor, made of low-alloy steel, handles temperatures of about 5000 deg R in a relatively simple manner.

Somewhat the opposite approach appears to have been made in the gas-turbine and turbojet field, where considerable research and development has been carried out in metallurgy and ceramics in order to permit relatively small increases in operating temperature (with attendant marked increases in efficiency). It is recognized that there are several fundamental differences between the problems of the gas turbine and those of the rocket motor, but perhaps it is appropriate for the rocket engineers to commend to the turbine people the usefulness of some rocket-design points.

In the writer's mind, a principle which is secondary only to regenerative cooling in importance, and one which must be given greater emphasis, is the protection of metal surfaces from oxidizing action of the combustion gases. Without such protection, oxidation tends to promote surface roughness which in turn promotes higher heat-transfer rates, higher surface temperature, and more accelerated oxidizing, until the material fails or melts away. Two methods of protection employed in the rocket motor are control of the local composition of the gases near the wall by proper injector design (e.g., injection of the fuel outside the oxidizer as shown in Figs. 9, 11(*b*), and 11(*c*) of the author's paper), and blanketing of critical zones with a reducing layer of fuel (e.g., use of "film-cooling" as in the A-4, Fig. 5).

Short-time durability is achieved in simpler designs, as the author points out, by lowering combustion temperatures through the expedient of operating the motor at fuel-rich mixture ratios. It should be noted that here a protective reducing atmosphere is a natural by-product. The turbojet, in contrast, has generally employed extremely lean mixture ratios, using air as a cheap diluent to lower flame temperatures. The temperatures have, to date, been low enough to permit the use of alloy metals without too great a need for design stratagems which give protection of turbine blades and chamber from oxidation. It should certainly be added that the temperature- and oxidation-resistant materials developed for oil- and gas-power use are valuable allies to design in modern liquid-rocket work.

The author mentions the work of Reaction Motors Inc., AeroJet Engineering Corporation, and the Jet Propulsion Laboratory GALCIT during the war years. The list is not complete without mention of another agency active throughout this period (and one which is close to the writer's heart), the Navy Bureau of Aeronautics Project located at the U. S. Naval Engineering Experiment Station, Annapolis, Md. The N.E.E.S. Project was established in May, 1941; its initial assignment was the development of a nitric-acid-type rocket unit for the jet-assisted take-off of flying boats, a task which was completed in the spring of 1943. The project's scope was meanwhile extended to cover broad research and development in the liquid-rocket field, with increasing emphasis on the powering of guided missiles. The group worked in close contact with Dr. R. H. Goddard whose activities were centered there from 1942 until his death in 1945. The project made numerous contributions to the art. It is to be hoped that in the near future the Navy will release an account of its work, adding to the documentary background which has been so well outlined by Mr. Wyld.

Author's Closure

The author agrees with Mr. Youngquist that the design philosophy represented in the rocket motor, especially in regard to cooling methods, should be applicable to many other combustion devices, such as gas turbines. The great difficulties encountered in dealing with temperatures of the order of 1800 F in gas-turbine work are in striking contrast to the comparative ease with which rocket nozzles withstand 5000 F for prolonged periods, without using special heat-resistant materials. Such well-known principles of rocket technique as regeneration, film cooling, and control of chamber temperature distribution by refined injector design, are all applicable to many other combustion problems outside of the rocket field. Rocket research has also resulted in remarkable progress in producing efficient high-intensity combustion, and many rocket auxiliary devices (such as control valves and high-speed pumps) have wide possibilities for general engineering applications. The liquid-propellant rocket, like the turbo-

[7] Industrial Engineer, Wilmington, Del. Member A.S.M.E.

[8] Yuma, Arizona.

[9] Special Research Engineer, Engineering Division, The Glenn L. Martin Company, Baltimore, Md. Jun. A.S.M.E.

[10] "The Liquid-Propellant Rocket Motor," by J. H. Wyld, Mechanical Engineering, vol. 69, June, 1947, pp. 457–464.

jet engine, is undoubtedly destined to act as a pacemaker for many other power plants and combustion devices of a more everyday sort, and serve as a kind of "Indianapolis Speedway" test for many new techniques in the field of heat energy.

The author also concurs with Mr. Youngquist's hope that a full account of the pioneer rocket work of the U. S. Naval Engineering Experiment Station at Annapolis, Md., will eventually be available. The author's company worked in close collaboration with this agency throughout the recent war, and several important new rocket devices were evolved from this co-operative work, including the first successful flight tests of a liquid-oxygen JATO unit in January, 1944, and the subsequent development of the first American rocket power plant for guided missiles. The work of N.E.E.S. will someday make a very interesting chapter in the colorful history of rocketry's early days.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code may communicate with the Committee Secretary, A.S.M.E., 29 West 39th St., New York 18, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all members of the Committee. The interpretation, in the form of a reply is then prepared by the Committee and is passed upon at a regular meeting.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of June 27, 1947, and approved by the Council on Aug. 6, 1947.

CASE No. 897 (Reopened)

(Special Ruling)

Inquiry: May chrome-nickel steels as such, or alloyed with columbium, titanium, or molybdenum, be used in the construction of unfired pressure vessels under A.S.M.E. Code rules?

Reply: Chrome-nickel steels as such, or alloyed with columbium, titanium, or molybdenum, may be used in the construction of unfired pressure vessels under the Code without consideration for their corrosive properties, with the following limitations:

(Par. 1 remains unchanged)

[*Par. 2 remains unchanged: add the following item III under (a)*]:

(III) The addition of columbium to the M grade is permitted. The amount should not exceed that specified in Specification SA-240 for the C grade. For preservation of corrosion resistance and avoidance of sigma phase (brittle) material a more restricted analysis than permitted by Specification SA-240 has been found advisable as follows:

Carbon, max, per cent, 0.07
Chromium, per cent, 17.50–19.00
Nickel, per cent, 13.00–14.00
Molybdenum, per cent, 2.00–2.50 (2.25 preferred)
Columbium, max, per cent, 9 times carbon content, 0.90
Manganese, min, per cent, 1.50
Silicon, max, per cent, 0.75
Sulphur, max, per cent, 0.03
Phosphorus, max, per cent, 0.03

This grade of material shall be marked "Mc" for identification.

(3) *Heat-Treatment.* Heat-treatment of the completely welded vessel by one of the following procedures, (**a**), (**b**), or (**c**), is mandatory for all vessels built in accordance with Par. U-68 construction and for all vessels built in accordance with Par. U-69 construction when the thickness is over $^1/_2$ in. Heat-treatment by either (**a**) or (**b**) procedure is desirable for other vessels from the standpoint of corrosion resistance. For vessels not to be heat-treated after welding, the material shall be heat-treated by the appropriate procedure either (**a**) or (**b**) as the last heating operation before welding. In this case the reduction of the corrosion resistance in the weld zone should be recognized. It is recognized that under some conditions of service, vessels of any of the four materials covered by this Case which have not been heat-treated after fabrication give satisfactory operation from the corrosion standpoint.

(**a**) Heat the material or the vessel to 1900 F to 2000 F for Grades S, C, and T and to 1950 to 2050 F for Grades M and Mc. Hold at this temperature for one hour per inch of maximum thickness, but in no case less than one half hour. Quench all parts of the plate or vessel uniformly and as rapidly as possible. For Grades S, M, and Mc, the time consumed in cooling from 1700 F to 1000 F shall not be more than three minutes. The rapid cooling shall be continued below this temperature

NOTE: Austenitic chrome-nickel stainless steels, when in a condition of internal stress and exposed to certain aqueous chloride solutions, may fail by stress corrosion cracking. Consideration should be given to the possibility of stress corrosion cracking in this and other corrosive environments to which the vessel may be exposed, in cases where the vessels are to be quenched in accordance with the preceding paragraph.

(**b**) Heat the material or the vessel to 1550 F minimum for Grades C and Mc and to 1550 to 1650 F for Grade T. This treatment is applicable to Grades C, Mc, and T, only. Hold at these temperatures for 2 hr. per inch of maximum thickness but in no case less than 2 hr. Cool in still air in the furnace.

(**c**) Heat the vessel to at least 1300 F in accordance with the rules of Par. U-76 of the code, except that the rate of cooling may be increased. This heat-treatment is intended for stress relief after welding but may be employed to produce a desirable combination of physical properties meeting other code requirements, at the same time providing sufficient corrosion resistance for the operating conditions. It may be applied to vessels made of any of the authorized grades except Grade Mc. When heat-treatment below 1550 F is used for vessels made of Grades C and T material, a free bend test specimen of the same material as in the shell of the vessel, and welded by the same procedure, shall be made, heat treated with the vessel and tested. The test results shall meet the requirements of Section IX of the code for the class of construction involved. Reheat treatment of the vessel and another specimen at a higher temperature is permitted as often as may be necessary to pass the test.

(4) *Thickness Limitations.* Fusion welded, thickness of shell, in inches:

Grade		S		M		Mc, C, or T
U-68	a	$1^1/_2$	a	$1^1/_2$	a	$1^1/_2$
			c	none	b	none
U-69		$^3/_4$		$^3/_4$		$^3/_4$
U-70		$^3/_8$		$^3/_8$		$^3/_8$

[a, b, and c refer to heat-treatments under (3)].

(5) *Pressure Limitations.* Omit.

(6) *Temperature Limitations.* Degrees Fahrenheit:

U-68 from —320 to max for which allowable stress is given in Table U-2 for each grade.

U-69 from —320 to 600 for all grades.

U-70 from —20 to 250 for all grades.

Impact tests provided in Par. U-142

hall be met for any one of the following conditions: (1) When materials are used below —20 F, or (2) when Grade Mc material that is not within the recommended analysis range is given heat-treatment 3 (*b*), or (3) when Grade M material is given heat-treatment 3 (*c*) at temperatures under 1650 F.

For operating temperatures above 600 F, Grades C and T should preferably be given the heat-treatment specified in (3) (*b*).

(7) *Allowable Working Stresses. (No change.)*

(8) *Welding. No change in (a) to (e), except to change "class" to "grade." Add the following to the first sentence of (e):*

Composition of the deposited metal shall be within the following limits except that when the fabricator is of the opinion that a physically better joint can be made by departure from these limitations and the user and the inspector are satisfied that the corrosion resistance will be sufficient for the intended service, these limitations may be waived provided any heat-treatment performed on the finished vessel shall be in accordance with 3 (*a*) above: Columbium, nickel, and molybdenum contents shall be within the same range as the parent metal.

(9) (*No change*).

CASE No. 941 (Reopened)

(*Special Ruling*)

Inquiry: It is permissible to construct welded unfired pressure vessels in accordance with Par. U-68, of high tensile manganese molybdenum steel conforming to A.S.T.M. Specifications A 204-38, modified as follows:

Carbon, max, per cent	0.22
Manganese, max, per cent	1.50
Phosphorus, max, per cent	0.04
Sulphur, max, per cent	0.04
Silicon, per cent	0.15–0.30
Molybdenum, per cent	0.40–0.70
Tensile strength, psi	90,000–105,000
Yield point, min, psi	55,000
Elongation, min, in 2 in., per cent	$\frac{2,300,000}{\text{tens str}}$

Reply: It is the opinion of the Committee that it is permissible to construct welded unfired pressure vessels of the steel specified in the inquiry under the provisions of Par. U-68 with the following additional provisions:

(1) The maximum thickness of shell or head shall be $2^1/_2$ in. Plate for shells or heads over $^5/_8$ in. in thickness shall be normalized at 1650 F to 1700 F;

(2) The maximum allowable working stress shall be 18,000 psi;

(3) The service temperature shall not exceed 450 F;

(4) The material shall be preheated to as high a temperature as practicable and held there throughout the welding operation;

(5) Weld reinforcement shall be removed;

(6) After stress relief the vessel shall be cooled slowly in the furnace to less than 600 F with the furnace doors closed;

(7) Welded test plates shall be made from the same lot of material, and receive the same heat-treatment as the vessel itself.

CASE No. 1051

(*Special Ruling*)

Inquiry: May welded-in rings be used in place of flanged-in construction for a manhole in the head of a fire-tube boiler?

Reply: It is the opinion of the Committee that the intent of the Code will be met by a welded-in manhole ring provided the minimum thickness of the ring is not less than the thickness of the head and in no case less than $^3/_4$ in., and the depth of the ring shall be not less than 4 times the thickness of the head. The welding shall conform to Par. P-186.

CASE No. 1053

Inquiry: Is it permissible to use atomic-hydrogen welded and redrawn nickel-copper-alloy tubes meeting the physical and chemical requirements of Specifications SB-163 to SB-165? If so, what would be the allowable design stresses for this material?

Reply: It is the opinion of the Committee that the material described in the inquiry may be so used and that the stress allowances for internal pressures shall be 85 per cent of those given for these specifications in Table U-3 for annealed pipe or tubing.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Heat Pumps

HEAT PUMPS. By Philip Sporn, E. R. Ambrose, and Theodore Baumeister. John Wiley & Sons, Inc., New York, N. Y., 1947. Cloth, $5^1/_2 \times 8^1/_2$ in., 188 pp., illus., $3.75.

REVIEWED BY E. B. PENROD[1]

MECHANICAL engineers, architects, and manufacturers will welcome this book written by men of practical experience. The authors, officials, and consultants for the American Gas and Electric Service Corporation of New York City, have had wide experience in designing and operating heat-pump systems for year-round air conditioning. As a matter of fact the American Gas and Electric Service Corporation has installed eight heat-pump systems on its properties since 1934.

The introductory chapter contains an excellent review of the thermodynamics of compression refrigeration cycles. Readers who have not made a formal study of thermodynamics will probably have to supplement this chapter by referring to a textbook on thermodynamics before they can grasp the physical significance of the coefficient of performance of a refrigeration compressor. On the other hand the mechanical-engineering graduate will find this chapter both refreshing and instructive. The table which gives the comparative properties and performances of refrigerants for heat-pump service will be useful to the design engineer when the choice of a refrigerant has to be made.

The heat-pump system is referred to rightly as a refrigeration plant used for heating and cooling. For air conditioning, the heat-pump systems are classified as air to air, water to air, air to liquid, and water to water. These four basic types are described carefully by the use of schematic diagrams.

The chief factors which affect the choice of heat-pump design are: climatic conditions, type and size of the building, and heat source. These are considered in detail throughout the book.

Obtaining the maximum coefficient of performance, keeping the installation and operating cost at a minimum, and select-

[1] Head, Department of Mechanical Engineering, College of Engineering, University of Kentucky, Lexington, Ky.

ing equipment which comprises the heat-pump system are important problems which confront the designer. The authors give an excellent account of the selection of compressors, heat exchangers, fans, and automatic controls.

The air-to-air design is restricted chiefly to dry climates where the outdoor temperatures never fall below 38 F. When the air heat pump is installed in humid climates where the outdoor temperatures fall below 26 F the "outside coil" will frost over, particularly for outside air temperatures ranging from 26 to 38 F. A large portion of one chapter is devoted to methods of defrosting the outside coils of the air-heat-pump systems. Although none of the methods described will be satisfactory for the domestic heat-pump installations, they may be used in large commercial heat-pump plants where an operating engineer is in charge. At the present time the problem of defrosting the outside coils, when the atmosphere is the heat source, has not had a satisfactory solution.

In an excellent discussion of heat-pump systems for industrial applications other than air conditioning, the authors point out that there are ample opportunities for applying the heat pump for evaporation, distillation, concentration, drying, and desiccation. Many industrial heat-pump cycles are described and some consideration is given to Brown Boveri installations in Switzerland.

The attention given to the economics of the heat pump and its effect on the power-system load curve will be most useful to the electric utility. Of general interest are comparative heating costs, equipment and installation cost, effect on required system capacity, and potential load of the heat pump.

An illustrated description is given of four heat-pump installations owned by the American Gas and Electric Service Corporation. The authors are to be commended for showing pictures of the heat-pump equipment since its application is so new in the field of air conditioning.

It is unfortunate that, except for the references, no consideration is given to the commercial heat-pump installations in the California area. The references to original papers at the end of each chapter are excellent and can be used advantageously to supplement material in the book.

Books Received in Library

ACCIDENT PREVENTION ADMINISTRATION. By F. G. Lippert. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1947. Cloth, 6 × 9¼ in., 159 pp., illus., diagrams, charts, tables, \$2.25. Detailed and specific guidance is provided in each of the various functions essential to effective accident prevention. The necessary steps are presented for the organization and operation of an accident-prevention program, including the collection and evaluation of data, training and follow-up procedures, union participation, and policy establishment. The subject is approached from the viewpoint of the persons responsible for the development, administration, and success of the program.

ALUMINUM ALLOY CASTINGS, their Founding and Finishing. By E. Carrington. Charles Griffin and Company, London, England, 1946. Cloth, 6 × 9¼ in., 326 pp., illus., diagrams, tables, 25s. This comprehensive work covers all processes of aluminum founding from the pattern to the finished, inspected casting. In addition to the basic melting and casting activities, there are also chapters on sand control, die preparation, dressing, and repairing, after-treatment of the cast surfaces, and machining. The general organization and operation of an aluminum foundry are considered, and extensive lists of references accompany the chapters.

CALCULATING HIGH VACUUM SYSTEMS, PB-50919. By W. P. Dryer. 39 pp. NEW DEVELOPMENTS IN VACUUM ENGINEERING, MD-DC 52. By R. B. Jacobs and H. F. Zuhr. 38 pp. Hobart Publishing Co., Washington, D. C., 1946. Paper, 8½ × 10 in., diagrams, tables, \$3 each. These two publications are part of a series of special technical reports released by the Atomic Energy Commission. One of them gives methods and formulas for the calculation of the size of equipment used in creating high vacuum in vessels of industrial size. The other discusses vacuum-testing methods; describes, in particular, techniques for leak detection developed with the mass spectrometer; and indicates the general utilization of those techniques.

ENGINEERING, SCIENCE, AND MANAGEMENT WAR TRAINING, Final Report. By H. H. Armsby. Bulletin 1946, No. 9. Federal Security Agency, U. S. Office of Education. Paper, 6 × 9 in., 161 pp., diagrams, tables, \$0.35. A brief, factual outline is presented of the origin, development, principal operating characteristics, and general results of the college-level war-training program conducted from 1940 to 1945. Part 1 is a narrative account of the basic principles, policies, and procedures, the contribution to the war effort, and the resulting permanent educational values. Part 2 sets forth in greater technical detail the authorizations, organizations, and methods of administration employed. There is a partial bibliography of articles from publications other than those of participating institutions.

FERROUS METALLURGICAL DESIGN. By J. H. Hollomon and L. D. Jaffe. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1947. Cloth, 5¼ × 9¼ in., 346 pp., illus., diagrams, charts, tables, \$5. Scientific principles and modern viewpoints are presented that can be applied to the selection of steels and to the understanding of their mechanical properties. The book constitutes an exposition of the theory that the design of steels should be based upon a knowledge of the transformations that occur in steels, of their mechanical behavior, and of heat flow during heat-treatment. Such topics as hardenability, temperability, and quench-cracking are dealt with in separate chapters. There is a 28-page bibliography.

MACRAE'S BLUE BOOK, America's Greatest Buying Guide and Hendrick's Commercial Register, 54th annual edition. MacRae's Blue Book Co., Chicago, Ill., 1947. Cloth, 8 × 11¼ in., 3740 pp., illus., \$15. This annual reference volume lists all manufacturers in the United States under a detailed product classification. The listing under each product is alphabetical by company name. A complete alphabetical listing of company names, with capital ratings and local distributors, precedes the classified section. A 340-page trade-name index is included at the back of the volume.

PHÉNOPLASTES, Bakélites. (Matériaux de Synthèse.) By P. Monthéard, préface de J. Duclaux. Dunod, 92 Rue Bonaparte (VI), Paris, France, 1947. Paper, 5½ × 9 in., 171 pp., diagrams, tables, 330 fr. Following a discussion of the constitution of phenolic resins, the author describes raw materials, processes of manufacture, and uses of the phenolic plastics. Succeeding chapters deal with the properties and molding technique of these plastics, special modifications by and with a variety of other substances, and the identification and determination of phenolic resins. A special chapter is devoted to the action of formaldehyde and other aldehydes on other substances than phenols.

PLASTICS MOLD DESIGN. By C. C. Sachs and E. H. Snyder. Murray Hill Books, New York, N. Y., and Toronto, Canada, 1947. Fabrikoid, spiral binding, 9 × 12¼ in., 77 pp., plus 14 charts, illus., diagrams, tables, \$4.50. Part 1 briefly covers drafting-room practice and materials for mold construction. Part 2 takes up the actual design procedures for compression molding, transfer molding, injection molding, and extrusion dies, including the causes and remedies of faults. A pocket at the back of the book contains a group of full-sized completely dimensioned working drawings of plastics molds.

POWDER METALLURGY, a Report of the Watertown Arsenal Laboratory. By A. Squire, reproduced by arrangement with Office of Technical Services, United States Department of Commerce, by Mapleton House, Brooklyn, N. Y. April, 1947, paged in sections, Paper, 5¼ × 8 in., illus., diagrams, charts, tables, \$8. Nine reports are brought together in this publication, chiefly concerned with the characteristics and properties of iron powders and iron-powder compacts under varying conditions of state, treatment, or processing. The exception presents a critical survey of powder-metallurgy application in ordnance design.

PRECISION HOLE LOCATION for Interchangeability in Toolmaking and Production, including Woodworth Circular Tables. By J. R. Moore. Moore Special Tool Company, Bridgeport, Conn., 1946. Fabricoid, 7 × 10¼ in., 448 pp., illus., diagrams, charts, tables, \$3. This book contains a comprehensive review of hole-location practices and the development of engineered methods consistent with the principle of interchangeability. The three fundamental steps in hole location are defined, and the principles are analyzed. With this background a typical die is carried through as illustration with emphasis on the likely errors which must be overcome. The precision jig borer and jig grinder produced by the author's company to accomplish the desired results are described with operational detail. Diagrams and tables covers the location of from 3 to 100 holes on circles of any diameter.

A.S.M.E. NEWS

And Notes on Other Engineering Societies

Compiled and Edited by A. F. Bochenek

World Need for Sound Management Stressed at Eighth International Management Congress

Stockholm, Sweden, July 3 to 8

WITH fanfare of trumpet and beat of drum, but with stern challenge to progressive management, public and private, to provide the security and abundance for the individual on which economic peace and political peace depend, the Eighth International Management Congress was formally opened in Stockholm on July 3, 1947. When the Congress closed on July 8, 1947, the headlines of the Stockholm papers unanimously acclaimed it as a *leende* or "smiling" congress, the smiles arising from deep satisfactions of the splendid hospitality, the fine fellowship among the participants, and the lift of heart that came from a discovery of common concern and a common desire to co-operate among the nations in the problems of more effective management.

The Background

Delayed six years by the war and one year by the difficulties of postwar communication between the nations, this was the eighth in the series of congresses under the auspices of the International Committee on Scientific Management, better known throughout the world as C.I.O.S., from the French translation, Comité International de l'Organization Scientifique. The previous congress in Washington in 1938 came to a close under the shadow of marching autocracy but with some hopes that 1941 would see a Swedish congress. The first congress in Prague in 1924 was held at the invitation of the new-born Czech Republic, which particularly desired to gain from the distilled experience of the United States of America. There was a similar atmosphere surrounding the latest congress, with the representatives of other countries anxiously seeking out the delegates from the United States of America to learn from the experiences derived during the war, when this nation astounded the world by its productive power.

Participation

There were over 1100 participants from twenty-seven countries; Sweden about 600, Great Britain 190, the United States of America 115, down to one each from Armenia, Brazil, Greece, India, and Rumania. There were large delegations from France, Denmark, Holland, Belgium, Norway, Finland, and Switzerland, as well as from far-off Australia and South Africa.

Program Pattern

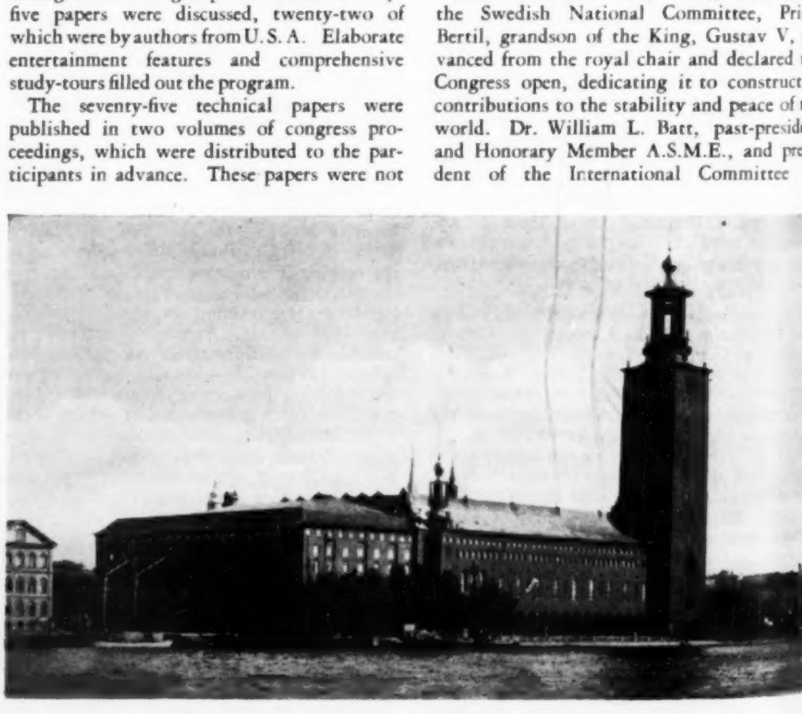
In addition to the opening and closing sessions, there were three plenary sessions at which the addresses were presented without discussion and fourteen technical sessions arranged in four groups at which seventy-five papers were discussed, twenty-two of which were by authors from U. S. A. Elaborate entertainment features and comprehensive study-tours filled out the program.

The seventy-five technical papers were published in two volumes of congress proceedings, which were distributed to the participants in advance. These papers were not presented by their authors but were summarized by a "rapporteur" at each session who posed questions for discussion from the floor.

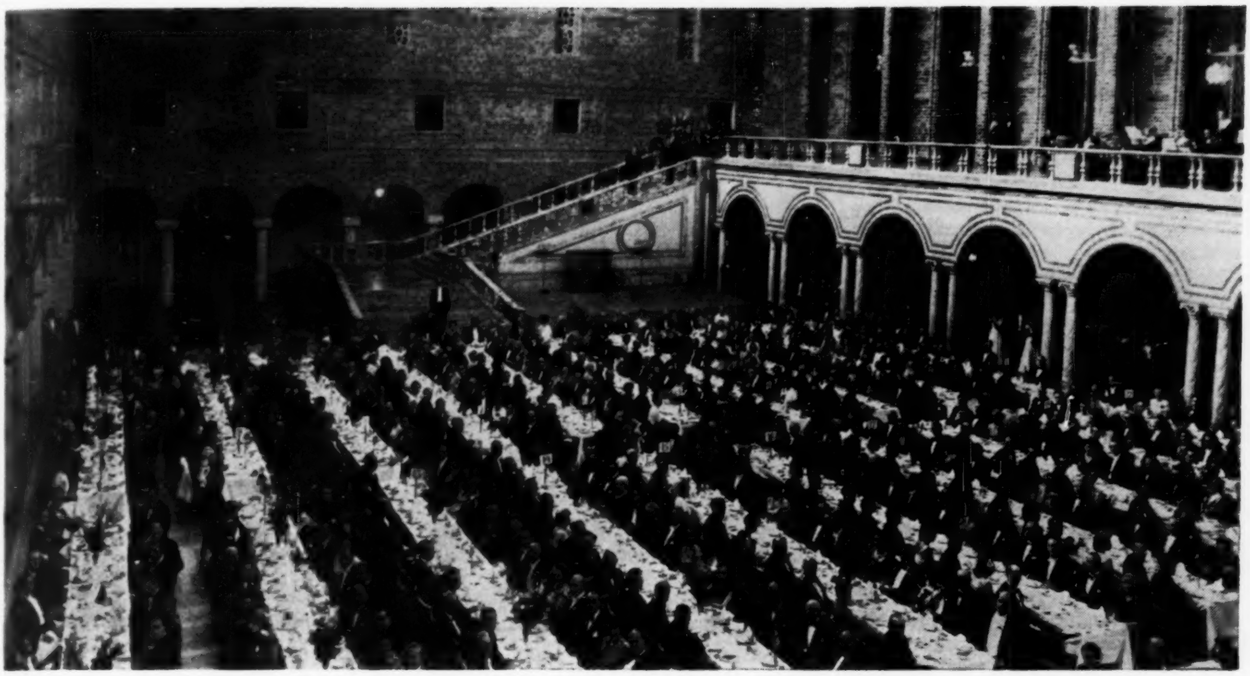
A third volume of proceedings will be published to include the addresses at the opening, closing, and plenary sessions, and a résumé of the discussion at the technical sessions.

The Opening Session

On July 3, 1947, in the handsome Concert Hall where the Nobel Prize ceremonies are held annually, after a few graceful words of welcome from K. F. Göransson, chairman of the Swedish National Committee, Prince Bertil, grandson of the King, Gustav V, advanced from the royal chair and declared the Congress open, dedicating it to constructive contributions to the stability and peace of the world. Dr. William L. Batt, past-president and Honorary Member A.S.M.E., and president of the International Committee on



TOWN HALL, STOCKHOLM, WHERE THE BANQUET OF THE EIGHTH INTERNATIONAL MANAGEMENT CONGRESS WAS HELD



THE BANQUET OF THE EIGHTH INTERNATIONAL MANAGEMENT CONGRESS IN THE TOWN HALL, STOCKHOLM, SWEDEN, JULY 5, 1947

Scientific Management, then gave his presidential address which will be published in full in the October, 1947, issue of MECHANICAL ENGINEERING.

The following excerpts from his opening remarks are appropriate:

"Almost without exception, the economy of every nation in the world has been destroyed outright, or subjected to new and unpredictable stresses.

"The maps of the world have new significance and strange complexions.

"Never has there been so overwhelming and demanding a need for sound and progressive management, for in the light of the new possibilities of science and industry and the growing interdependence of the various national economies of the world, it is not an idle observation to say that merely producing more is not alone enough; to this knowledge must be added the best possible skills and techniques of distribution and the utmost influence on consumption, so that what man has produced, he may be able to purchase and use.

"Our Swedish hosts have laid great and proper emphasis on this intimate relationship between economic progress and peace. They have pointed out that the free exchange of ideas and knowledge in all fields of management, private as well as public, is a natural means of restoring and raising the standard of living throughout the world; that direct contact between individuals and organizations working for efficient management in different countries will help restore international understanding and confidence.

"They remind us that cultural, social, and material progress, particularly in the light of the expanding future, is closely related to more economic utilization of our production assets, and that improved management is the keenest tool with which this progress can be hastened.

"The statement of their objectives underscores the theme of this Eighth International Management Congress. "That theme is: How can we find ways to raise man's standard of living and give him greater satisfaction from the society in which he lives.

"The specific objectives of our program in the immediate days ahead have been well stated by the Swedish National Committee. They are: (1) To provide a meeting ground for the exchange of ideas and experience between people in responsible positions in different countries; (2) To appraise the progress made in various fields of management during the many years since the last Congress; (3) To assay the most promising directions for further development and application; (4) To discuss ways of allaying management-labor differences in the spirit and recognition of joint responsibility for the common good; (5) To examine ways and means for promoting improved education and interest in efficient management and for raising the level of economic thinking."

Greetings followed from Lord Leverhulme of Great Britain, L. H. Ferasson of France, and H. P. Christensen of Denmark. Then with introductions of C.-B. Nathhorst, chairman of the Congress Committee and H. Nystrom, chairman of the Reception Committee, the session was adjourned.

The Banquet

The dramatic event of the congress was the banquet on Saturday evening, July 5, 1947, in the famous Stockholm Town Hall. Eleven hundred guests in gala attire gathered to marvel at the natural warmth and beauty of the hall which required no artificial decoration; to enjoy the good dinner and the fine fellowship made easy by the careful seating arrangements; and to cheer the black-and-white garbed waiters as they marched eight abreast down the massive staircase with trays held high. The members noticed the menus on thin sheets of stainless steel and the cigars and cigarettes, specially marked for the occasion with the Congress insignia as items of special attention from their Swedish hosts. From time to time during the dinner, the toastmaster, Harry Nystrom, would ascend to the lectern and introduce a speaker. In this way, Prince Bertil, K. F. Göransson, chairman of the Swedish National Committee, William L. Batt, president of C.I.O.S., and Magnus Tigerschiöld were brought into the program and spoke briefly in a happy vein of the excellent progress of the Congress. After dinner, Joel Berglund of the Royal and Metropolitan Operas brought hearty applause for his program of arias and Swedish songs.

The party moved into the courtyard to walk in the soft northern afterglow while the floor was being cleared. Then after a remarkable gymnastic exhibit by 12 Swedish girls, there was dancing until late, when an unexpected shower revealed that there were no taxis and the Swedish Committee showed its resourcefulness by chartering buses which delivered their gay evening-garbed passengers safely to their doorsteps.

The Plenary Sessions

The first plenary session was devoted to the philosophy and application of scientific management and the addresses were as follows:

Progress in Scientific Management, Harlow S. Person, U. S. A.

The Evolution of the Philosophy of Scientific Management, Jean Chevalier, France.

The Wider Application of Science in Management, Lord Leverhulme, Great Britain.

This group of addresses contained a wealth of material of value not only to the historian but to the practitioner of management.

In Dr. Person's absence, his address was given by Professor Erwin H. Schell, member A.S.M.E., U. S. A. At its close, President Batt of C.I.O.S. bestowed the C.I.O.S. Gold Medal upon Dr. Person for his important scientific work in management, and requested Professor Schell to present the medal to Dr. Person with the good wishes of C.I.O.S. and the Congress.

The Second Plenary Session was on regional and local planning in modern society, and contained three addresses:

The French Plan for National Modernization (the Application of Scientific Management at the National Level), by the Commissariat Général du Plan de Modernisation et d'Équipment, presented by Jean Chevalier.

An American Approach to National Planning by Private Citizens, by Hans Christian Sonne, U. S. A.

Private Industry and Local Community Planning, by Nils Danielsen, Sweden.

The French paper described the process used in arriving at a national plan to restore public and private machinery and equipment destroyed by war, by developing national production, by increasing productivity, by securing full employment, and by raising living standards. The paper explained the need of an over-all plan to co-ordinate efforts and to keep in mind long-term objectives.

In contrast was Mr. Sonne's description of the results attained by the National Planning Association in the United States, which brings management, labor, and government into co-operation to suggest solutions of current ecnomic problems for the use of legislators.

The Swedish paper gave a useful account of the close interrelations necessary between private industry and the planning of community services, particularly housing and recreational facilities.

The Third Plenary Session was on industrial relations and comprised papers on:

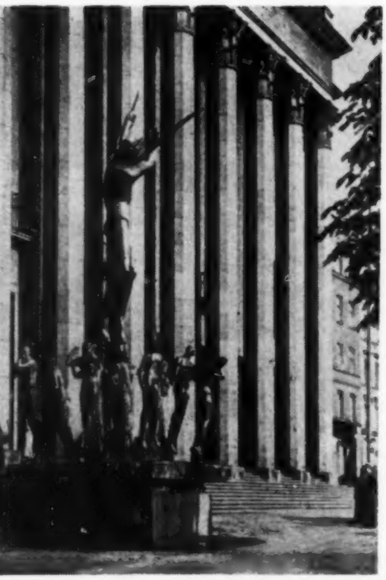
Collective Bargaining in Sweden, by the Swedish Employer's Confederation in Conjunction With the General Federation of Swedish Trade Unions and the Swedish Central Organization of Salaried Employees.

British Wartime Experience With Employer-Employee Negotiations, Consultation and Co-operation, by Sir Frederick Legget, Great Britain.

These papers presented a mature experience in industrial relations and attracted great interest.

The Technical Sessions

The four groups into which the fourteen technical sessions were assigned present a difficult problem of quick appraisal. That must come from a careful reading of the record. In general, the discussion was spirited and in many cases extended beyond the allotted time. There was comment in the corridors that the clocks ran too quickly and there was not enough time to question the American authors. One of the interesting observations was that so much progress had been made in countries that had suffered from war handicaps. The sessions on home management and farm management, somewhat of a novelty on



THE CONCERT HALL, STOCKHOLM, SWEDEN, HEADQUARTERS OF THE CONGRESS WHERE MOST OF THE MEETINGS WERE HELD

congress programs, attracted good attention and pointed to the need of more extended treatment of these subjects in future congresses.

Except for the session on modern housing, there were papers from U. S. A. in all sessions. The titles of these sessions and the authors from U. S. A. are as follows:

Business Administration

Business Management in U. S. A., by A. E. Dodd, Fellow A.S.M.E.

Evolution in Organization During the Past Decades, by A. Hopf, member A.S.M.E.

Home Management

Management and the Home, by L. M. Gilbreth, Fellow A.S.M.E.

Education for Management

Formal Education in Scientific Management, by Erwin H. Schell, member A.S.M.E.

Education of Industrial Executives in Scientific Management, by Wallace Clark, Fellow A.S.M.E.

Union Education of Workers in Management Procedures, by C. S. Golden, U. S. A.

Production Administration

Progress in Production in the U. S. A., by L. C. Morrow, member A.S.M.E.

Significance of the Productivity of Labor, by John A. Willard, member A.S.M.E.

Progress in Industrial Work Simplification, by H. B. Maynard, member A.S.M.E., A. H. Morgenson, and D. B. Porter, member A.S.M.E.

Office Management

Progress in Office Management in the U. S. A., by C. L. Maze, U. S. A.

Progress in Personnel Administration, by G. B. Arthur, U. S. A.

Cost and Budgetary Control

Progress in Cost Control, by W. P. Fiske, U. S. A.

Agricultural Management

Progress in Scientific Farm Management, by D. M. Braum, U. S. A.

Product Development

Management Practice in New-Product Planning and Development in the U. S. A., by R. M. Cunningham, C. B. Tallman, and E. A. Boyan, U. S. A.

Selection and Training

Progress in Selection and Training of Workers, by J. W. Dietz and C. R. Dooley, U. S. A.

Quality Control

Progress in Quality Control, by J. M. Juran, member A.S.M.E., and R. E. Wareham, U. S. A.

Public Administration

Progress in Public Administration, by H. Emmerich, U. S. A.

Progress in Municipal Administration, by J. J. Furia, U. S. A.

Progress in Regional Planning in the U. S. A., by D. E. Lilienthal and G. R. Clapp, U. S. A.

Application of Scientific Management Principles to International Administrations, by D. C. Stone, U. S. A.

Distribution Administration

Progress in the Use of Engineering Techniques in Marketing, by A. C. Nielsen, U. S. A.

Trends in Distribution in the U. S. A., by D. C. Mitchell, U. S. A.

Social Program

The high lights of the social program were the informal reception at the National Museum of Fine Arts on the opening evening, an excursion to the Royal Summer Residence at Drottingholm on Sunday, July 6, featured by a performance of a Mozart Operetta in the 18th Century Court Theatre, and an excursion to the seaside resort at Saltsjobaden for dinner on July 7. Throughout the six days of the Congress, provisions were made for sight seeing, and for visits to the museums, to several factories and department stores and to points of special interest to the women, such as the Home Research Institute and the Friends of Art Weaving. Luncheon reservations had been made at the different interesting restaurants of Stockholm. The general result was that during the week, ample opportunity was afforded to all the visitors to see Stockholm.

The Closing Session

On the afternoon of July 8, the delegates gathered for the last time in the Concert Hall for the closing session with K. F. Göransson, chairman of the Swedish National Committee presiding. Professor G. Tornqvist, chairman of the Program Committee, presented a brief summary of the technical sessions. He was followed by William L. Batt, president of C.I.O.S., who pointed out that the Congress has ushered the management movement into what may be its most auspicious period where there is less tendency the world over to criticize innovation and development, as such, than at any time in history. Human beings everywhere are eager to live in a constructive atmosphere. Finally, he emphasized, the congress has established, in clearest outline, the fact that good management is an inherent responsibility of leaders everywhere and cannot be bound to any geographical area or to any class. He closed with words of hearty thanks to the Swedish hosts for their cour-

WILLIAM L. BATT, PRESIDENT C.I.O.S. WITH ASSAR GABRIELSON, PRESIDENT-ELECT, C.I.O.S.

teous, painstaking hospitality, which resulted in a highly successful congress.

After expressions of thanks from representatives of several countries, Prince Bertil left his royal chair, and with words of appreciation for the Eighth Congress and good wishes for the Ninth, declared the Congress closed.

The International Committee

During the Congress, the Executive Committee of C.I.O.S. was in session and at the adjournment of the closing session, a meeting of the International Committee on Scientific Management was held. This Committee has been made up of representatives of Belgium, Brazil, Czechoslovakia, France, Great Britain, Greece, Holland, Sweden, and the United States of America. The U. S. A. representatives present were Wallace Clark, Lillian Gilbreth, Charles Hatch, Thomas R. Jones, and John A. Willard, in addition to President Batt and Harry Hopf, Honorary Member of Council.

The principal business transacted was the selection of the following officers to serve until the next Congress: For president, Assar Gabrielsson, Sweden; for vice-presidents, Lewis H. Brown, U. S. A., E. Schlecta, Czechoslovakia, C.-B. Nathhorst, Sweden, Theodore Limperg, Holland, and Louis Ferasson, France.

A vacant place was left for Great Britain to be selected when the organization of the new British Management Council is completed.

Upon recommendation of the Swedish Committee, a new office was created, that of treasurer, and William L. Batt was selected to fill it. This new responsibility will not include the routine collection of fees and payment of expenses now performed by the secretary, but will be to assist the president primarily in the development of new sources of funds.

The following were elected to honorary membership on the Council: Lord Leverhulme, Great Britain, K. F. Göransson, Sweden, L. Urwick, Great Britain, and Harry Hopf, U. S. A.

Among the possible future objectives of C.I.O.S. the following were agreed upon: (1) Arrange for representation of C.I.O.S. in a suitable United Nations organization; (2) Promote the formation of management bodies in nonmember countries and secure their participation in C.I.O.S.; (3) Facilitate the interchange of management literature and bibliographies; (4) Establish standards of management terminology; (5) Study the Eighth Congress and recommend improved procedures for future Congresses. (Prof. Gerhard Tornqvist of Sweden accepted this responsibility.)

Canada, Norway, Finland, and Denmark were admitted to C.I.O.S.

A number of items were left for later meetings. These included the selection of a deputy-president, the choice of a secretary, and the final adoption of a budget. Although invitations for the Ninth Congress and intermediate special meetings had been received from Brazil, Poland, and Holland, decision was postponed to give the new president adequate opportunity to explore the problem and clear up the administrative problems that must be settled first.

Study Tours

The study tours which started on the close of the Congress, made up a network that covered Scandinavia. One group of 19 simultaneous tours of two days each visited industrial, agriculture, home, and scenic interests. Following these, there were four simultaneous recreation tours of a week for visits to Denmark, Finland, Norway, and the more remote parts of Sweden. These tours were well attended and enthusiastic reports were heard of the splendid manner in which they were conducted and the interesting developments that were revealed.

Participation From U. S. A.

Participation from the U. S. A. was organized by the National Management Council, the body which represents this country in C.I.O.S., and which in turn is made up of representatives of the Association of Consulting Management Engineers, American Management Association, The American Society of Mechanical Engineers (Management Division), Society for Public Administration, International City Managers Association, Life Office Management Association, National Office Management Association, and the Society for the Advancement of Management.

John A. Willard, member A.S.M.E. is chairman, A. M. Lederer, vice-chairman, and John Furia, secretary of the National Management Council. Charles H. Hatch, member A.S.M.E. as managing director of U. S. A. participation, had been engaged for over a year in developing the plans which resulted in the excellent representation from U. S. A. Erwin H. Schell, member A.S.M.E. was chairman of the Program Committee for the American papers for the Congress.

Of the 115 representatives from U. S. A., 85 traveled in a body on the S. S. *Drottingholm* from New York on June 20. During the trip, in addition to the opportunity for good fellowship which will always be a pleasant memory, skull practice for the Congress was held under the leadership of Charles C. James and Erwin Schell. Congress topics were discussed as were other matters of importance, such as the Taft-Hartley Law, and the general economic and industrial background of Sweden. The *Drottingholm* party was welcomed as it steamed up the river at Gothenberg, Sweden, by a cordial reception committee headed by Dr. Hilding Tornebohm, member A.S.M.E., and by two U. S. Navy flattops and two destroyers which had recently arrived with Annapolis men on a practice cruise. The afternoon of arrival was spent in a ride about Gothenberg and a visit to modern housing developments. The British party which had arrived that morning from London joined up in the evening for a pleasant dinner at the Liseberg, a most attractive amusement park, where the first steps in getting acquainted with the Swedish hosts were taken. The night was spent on board the ship and the next morning the party split to visit industries, shipyards, and museums. The largest party visited the SKF Works, where they saw modern inter-changeable manufacture of high quality in exemplary

SOME OF THE AMERICAN DELEGATES POSE WITH THEIR SWEDISH HOSTS

(*Seated, left to right:* Mrs. Alex N. Engblom, Jr., Sweden; William L. Batt, U. S. A.; Lillian M. Gilbreth, U. S. A.; and Alex N. Engblom, Sweden. *Standing, left to right:* Alonzo Flack, C. E. Davies, Andrew B. Holstrom, Mrs. H. B. Maynard, Don M. Braum, Mrs. A. B. Holstrom, H. B. Maynard, Mrs. Alonzo Flack, Wallace Clark, and J. P. Kottcamp, all U. S. A., and Alex N. Englom, Jr., Sweden.)

surroundings. After lunch they strolled through the attractive park to the special train which bore the British and American delegations to Stockholm for the Congress.

On the 4th of July, the delegation from U. S. A. was received by the American Minister to Sweden, Louis G. Dreyfus, and his wife. Later in the evening, they participated in an open-air celebration arranged by Swedish-American groups which consisted of addresses by Count Folke Bernadotte and the American Minister, and music and gymnastics. The congress participants then adjourned to supper and a brief speaking program by Count Folke Bernadotte, William L. Batt, and Eric Johnston.

After the Congress, about 30 returned on the S. S. *Drottingholm* on a rough foggy trip. Fifteen came a week later on the S. S. *Gripsholm* on a placid sea. The others scattered on errands to other parts of Europe.

A.S.M.E. Participation

The U. S. A. delegation included the following members of A.S.M.E. who were appointed honorary vice-presidents of the Society for the congress: William L. Batt, Philadelphia, Pa.; Wallace Clark, New York, N. Y.; C. E. Davies, New York, N. Y.; Alvin E. Dodd, New York, N. Y.; Alonzo Flack, New York, N. Y.; Lillian M. Gilbreth, Montclair, N. J.; Charles H. Hatch, Rock Hall, Md.; Andrew B. Holstrom, Worcester, Mass.; Harry A. Hopf, Ossining, N. Y.; Sidney Knight, New York, N. Y.; John P. Kottcamp, New York, N. Y.; Harold B. Maynard, Pittsburgh, Pa.; L. C. Morrow, New York, N. Y.; Erwin H. Schell, Cambridge, Mass.; Walter W. Tangeman, Cincinnati, Ohio; and John A. Willard, New York, N. Y.

All found colleagues in Sweden, who welcomed them heartily and a few were specially entertained by Alex. N. Engblom, Fellow A.S.M.E. and vice-chairman of the Swedish National Committee.

Two Outstanding Impressions

In retrospect, there are two outstanding impressions in addition to the impression of the Congress itself. First, recognition of the splendid Swedish Congress Organization, and appreciation for its accomplishments must be recorded. The plans were well laid and well executed. The Committee members were in constant attendance to anticipate the needs of their guests and the large staff was courteous and competent. Secondly, very few of the American participants had ever visited Sweden and it was a novel experience to them. Swedish industry and its craftsmanship, the realism of its industrial relations, the maturity of its culture, the cleanliness of its cities, the design of its housing, the alertness of its people and its long summer twilight, made lasting impressions and led to resolves to visit Sweden again. C. E. D.

ENGINEERS from 34 states, Canada, and three foreign countries attended the 1947 A.S.M.E. Semi-Annual Meeting held in Chicago, Ill., June 16 to 19, 1947.

Total attendance was 1265. Of these 777 were members, 406 guests, 17 students, and 65 women.

I.M.E. Centenary Celebration Memorable Event

THE Prime Minister of Great Britain and many members of his cabinet took part in the centenary celebration of The Institution of Mechanical Engineers held in London, June 8 to 13, 1947.

Awareness on the part of the Labor Government of the potential contribution of the engineers of Great Britain to the revitalization of British economy was indicated by Prime Minister Clement R. Attlee in his talk at the concluding banquet of the celebration held in the Guildhall on June 13. He said that the government was relying on the engineering profession for the forward look and the constant reaching for new objectives. He called upon engineers to insure economical use of man power and to provide the skilled production that Britain needs to keep her place in the world. Referring to Britain's great tradition of skill in engineering, he said that he believed British engineers were holding their own in that field.

The banquet was the climax of a memorable week of lectures, dinners, garden parties, and inspection trips during which many foreign engineers joined with members of the Institution to recall its eventful history and to discuss recent advances in the art and science of mechanical engineering around the world.

Official A.S.M.E. delegates to the celebration were Alfred Iddles, past vice-president and Fellow A.S.M.E., and director, The Babcock and Wilcox Company, New York, N. Y., and A. G. Christie, past-president and honorary member A.S.M.E., professor of mechanical engineering, Johns Hopkins University, Baltimore, Md.

The American delegation was graciously welcomed and was shown every courtesy. The following were among those who presented papers: Adolph Meyer, member A.S.M.E.; Paul Kiefer, Fellow A.S.M.E.; H. R. Ricardo, honorary member A.S.M.E.; W. Julian King, member A.S.M.E.; Willis H. Carrier, honorary member A.S.M.E.; T. W. F. Brown, member A.S.M.E.; and R. E. Doherty, Fellow A.S.M.E. Contributions by American engineers to the technical discussions were well received.

As senior member of the delegation, Professor Christie presented the certificate and A.S.M.E. pin of an honorary member to Lord Dudley Gordon, president of the Institution, at a special meeting of the full I.M.E. Council on June 12. William S. Newell, member A.S.M.E., president, Bath Iron Works, Bath, Me., was also present at the ceremony representing Eugene W. O'Brien, president A.S.M.E.

After the Council had assembled and Professor Christie and Mr. Newell had been escorted into the chamber, Professor Christie explained the A.S.M.E. practice of selecting for honorary membership in the Society engineers who had made distinct contributions to the art and science of mechanical engineering regardless of nationality and affiliation. He said that Lord Dudley Gordon had been recommended and elected because of his achievements as engineer, manager, and administrator in the fields of refrigeration and steel production.

In accepting the honor, Lord Dudley Gordon disclaimed any outstanding engineering achievement on his part to earn the award and held that the honor came to him as a tribute to the Institution as a whole, which he represented as president.

On the occasion of its centennial, the Institution has published the "History of The Institution of Mechanical Engineers." The volume gives an account of the origin and development of the Institution and a review of the engineering discussions that occupied its members during the first half of its existence. Engineering developments of the last 50 years have been omitted because they were considered too recent for a proper perspective and have been reserved for a future historian.

LORD DUDLEY GORDON, PRESIDENT OF THE INSTITUTION OF MECHANICAL ENGINEERS, RECEIVES CERTIFICATE AND LAPEL PIN OF AN HONORARY MEMBER OF THE A.S.M.E. FROM A. G. CHRISTIE, PAST-PRESIDENT AND HONORARY MEMBER A.S.M.E.

Tentative Program of the 1947 Conference on Petroleum Mechanical Engineering, Houston, Texas, Oct. 6 to 8

THE program of the A.S.M.E. National Conference on Petroleum Mechanical Engineering to be held at the Rice Hotel, Houston, Texas, Oct. 6 to 8, 1947, promises stimulating discussions on a wide variety of problems which have been the concern of mechanical engineers charged with the design and maintenance of the physical plants of the petroleum industry. The Conference is sponsored by the Petroleum Committee of the Process Industries Division of The American Society of Mechanical Engineers.

The twelve technical sessions scheduled on all phases of the industry, including materials, transportation, refining, production, and equipment, are expected to provide a host of new ideas, performance data on specific materials, new techniques and devices, and an account of some of the practical experiences which make up a part of the 1947 increment of achievement in the mechanical arts.

As a convenient reference and aid to the profession, all papers and discussion presented at the Conference will be published in The Proceedings of the Conference, which will be distributed to registrants. A registration fee of $5 will be charged for members and $10 for nonmembers.

The 1946 Proceedings is a 220-page volume containing 36 papers and more than 300 illustrations. Although the Proceedings have already been distributed, a few copies remain at Headquarters and may be purchased at $4.50 per copy. Orders should be addressed to Publication Sales, A.S.M.E. Headquarters, 29 West 39th Street, New York 18, N. Y.

The tentative program follows:

SUNDAY, OCT. 5

2:00 p.m. to 8:30 p.m.

Registration

MONDAY, OCT. 6

8:30 a.m.

Registration

10:00 a.m.

Materials (I)

Application and Handling of Foam, by E. E. Kerns

Corrosion of Oil-Well Equipment, by L. C. Case

Equipment (I)

Accessories for Good Operation of Storage Vessels, by F. L. Goldsby

Tube-Rolling Study—Part II, by M. Q. Colton

12:15 p.m.

Welcoming Luncheon

2:15 p. m.

Transportation (I)

Heavy-Crude-Oil and Fuel-Oil Handling, by E. L. Adams

The Application of New Designs in Plunger Pumps With Some Comments on the Handling of Viscous Crudes, by L. T. Gibbs and T. R. Aude

Materials (II)

Study of Weldments in Alloy Steels and in Alloys, by T. N. Armstrong

Field Welding and Stress-Relieving of Alloy Piping, by B. W. Farquhar

8:00 p.m.

Transportation (II)

Interfacial Characteristics of Products in Product-Pipe Lines, by S. S. Smith and R. K. Schultze

Supporting papers from Sinclair, Plantation, and Phillips Companies

Refining (I)

Internally Insulated Piping and Pressure Vessels for High-Temperature Service, by P. E. Darling

Paper on atopic in modern refining, by C. A. Knight

TUESDAY, OCT. 7

9:00 a.m.

Transportation (III)

Notes on Natural-Gas Transmission, by W. H. Stueve

Centrifugal Compressors for Natural-Gas Transmission (author to be announced)

Production (I)

Comparison of Prime Movers for Pumping Wells, by J. H. Field

Hydraulic Pumpers for Shallow Wells, by A. A. Hardy

2:00 p.m.

Inspection Trips

7:00 p.m.

Banquet

WEDNESDAY, OCT. 8

9:00 a.m.

Equipment (II)

Pressure-Vessel Design, O. R. Carpenter

Investigation of Stress in Vessels Under Internal Pressure, by T. L. White

Production (II)

Internal-Combustion Engine Power Applications for Rotary Drilling, by W. S. Crake

Some Factors, Influencing Selection of Factors of Safety in Casing Design, by E. N. Kemler

Refining (II)

2:00 p.m.

Effect of Leakage Around Cross-Baffles in a Heat Exchanger, by Arthur M. Whistler

History of Some Austenitic (18-8) Furnace Tubes, by C. S. Pugsley, Jr.

Production (III)

Free-Pumping System, by W. F. Slater

Subsurface Sucker Rod and Gas Lift Pumps, by R. L. Chenault

Bridge and Structural Engineering Congress Planned for 1948

THE International Association for Bridge and Structural Engineering will hold its next congress in Liege, Belgium, during September, 1948, it has been announced recently.

The congress will include five sessions devoted to the following subjects: Assembling devices and structural details in steel structures; developments in building structures in concrete and masonry; developments in long-span steel bridges; slabs and various curved structures of reinforced concrete; and analysis of safety and dynamic forces.

Members of the I.A.B.S.E. are invited to submit papers. The manuscripts must be in the hands of the General Secretary, Swiss Federal Institute of Technology, Zurich, Switzerland, before January 1, 1948.

A.S.M.E. Calendar

of Coming Events

Sept. 8–9, 1947
A.S.M.E. Instruments and Regulators Division Meeting
Chicago, Ill.

Oct. 6–8, 1947
Petroleum Committee of the A.S.M.E. Process Industries Division Meeting
Houston, Texas

Oct. 20–21, 1947
A.S.M.E. Fuels Division Meeting
Cincinnati, Ohio

Dec. 1–5, 1947
A.S.M.E. Annual Meeting
Atlantic City, N. J.

March 1–6, 1948
A.S.M.E. Spring Meeting
New Orleans, La.

May 30–June 5, 1948
A.S.M.E. Semi-Annual Meeting
Milwaukee, Wis.

Sept., 1948
A.S.M.E. Fall Meeting
Portland, Ore.

Nov. 28–Dec. 4, 1948
A.S.M.E. Annual Meeting
New York, N. Y.

A.S.M.E. to Participate in National Tool Congress

TWO Professional Divisions and one Special Research Committee of The American Society of Mechanical Engineers are sponsoring two of the five technical sessions planned for the Machine Tool Congress of 1947 to be held in several of the hotels in Chicago, Ill., Sept. 17 to 25, 1947. The Congress has been planned as a series of evening sessions so that the thousands of machine-tool users and manufacturers who will be in Chicago, Ill., for the 1947 National Tool Show sponsored by the National Machine Tool Builders Association will be able to participate in the program of significant addresses and technical papers by authorities in the machine-tool industry. The A.S.M.E. and seven other technical societies and trade associations are co-operating in the Congress. There will be a dinner preceding most of the Congress sessions.

The Machine Tool Show is to be held in the Dodge-Chicago Plant, 74th Street and Cicero Avenue, Chicago, Ill., Sept. 17 to 26, 1947. The show will consist of 12 acres of exhibits and will be twice as large as the last event of its kind held in Cleveland, Ohio, in 1935. More than 250 exhibitors will demonstrate new machine tools, forging machines, and other metal working machinery and equipment of all types and sizes.

The technical program follows:

THURSDAY, SEPT. 18

Continental Hotel, Gothic Room

Sponsors: Production Engineering Division and Machine Design Division of The America Society of Mechanical Engineers

Form Grinding, by J. L. Wilson, Thompson Binder Company, Springfield, Ohio

Fabricated Construction in Machine Tools, by J. F. Lincoln, member A.S.M.E., president, Lincoln Electric Company, Cleveland, Ohio

FRIDAY, SEPT. 19

Hotel Sherman, Old Town Room

Sponsors: American Society of Tool Engineers and the American Foundrymen's Association

Turning Points in the Metalworking Industry, by Myron S. Curtis, assistant director of engineering, Warner and Swasey Company, Cleveland, Ohio

When and How to Use Cast Iron, by T. E. Eagan, chief metallurgist, Cooper-Bessemer Corporation, Grove City, Pa.

MONDAY, SEPT. 22

Palmer House, Ballroom

Sponsors: National Electrical Manufacturers Association

Charles F. Kettering, Fellow A.S.M.E., research consultant, General Motors Corporation, Detroit, Mich., will be the main speaker

TUESDAY, SEPT. 23

Civic Opera Building, 38th Floor

Sponsors: Chicago Technical Societies Council

Machine Tools and the Philosophy of Production, by George Habicht, Jr., president, Marshall and Huschart Machinery Company, Chicago, Ill.

WEDNESDAY, SEPT. 24

Continental Hotel, Boulevard Room

Sponsors: Production Engineering Division and Special Research Committee on Metal Cutting Data and Bibliography of The American Society of Mechanical Engineers

Practice and Theory in Carbide Milling, by Michael Field, junior member A.S.M.E., Cincinnati Milling Machine Company, Cincinnati, Ohio

Recent Developments in Carbide Application, by J. R. Longwell and Fred W. Lucht, member A.S.M.E., both of Carboloy Company, Detroit, Mich.

VISITORS ON THE BEACH AT ATLANTIC CITY, N. J., ENJOYING WINTER SUNSHINE

(For the third time in its history the A.S.M.E. will hold its Annual Meeting away from New York, N. Y. The Chalfonte-Haddon Hall Hotels in Atlantic City, N. J., have been selected as headquarters for the A.S.M.E. 1947 Annual Meeting because of the excellent hotel and recreation facilities offered to members. The leisurely atmosphere of the winter season on the beach and along the boardwalk attracts thousands of visitors who enjoy unhurried shopping and relaxation. In such an atmosphere the program of the 1947 Annual Meeting may be expected to inspire a full measure of sociability and good fellowship which are always a part of Society meetings.)

I.I.R. Division to Hold Meeting in Chicago, Ill.

THE Industrial Instruments and Regulators Division of The American Society of Mechanical Engineers will hold its second annual conference at the Stevens Hotel, Chicago, Ill., Sept. 8 and 9, 1947.

Technical Papers

Four papers will be read at a technical session scheduled during the morning of the first day. The papers will be:

Application of Mechanical Cascade Control Systems, by J. M. Swarr

Floating-Scale Manometers, by W. D. Wood

Design of Instrument Gears, by G. W. Kuntney

A New System of Humidity Measurement, by W. F. Hickes

Various Mechanical and Electrical Digital Calculators and Their Uses, by Wallace J. Eckert

W. Julian King, director, Sibley School of Mechanical Engineering, Cornell University, Ithaca, N. Y., will be the main speaker at the banquet which is scheduled for Monday, Sept. 8. His subject will be "Personal and Professional Problems of Engineers—Common Aids and Barriers to Advancement."

Exhibit

The second day will be given to committee meetings of the Division and to inspection of the Exhibit, sponsored by the Instrument Society of America as part of its second annual meeting, Sept. 8 to 12, 1947, also to be held at the Stevens Hotel.

Joint Fuels Conference to Be Held in Cincinnati Oct. 20 and 21

FOR the tenth consecutive year the Fuels Division of The American Society of Mechanical Engineers will meet with the Coal Division of the American Institute of Mining and Metallurgical Engineers to discuss problems of the coal industry which are of mutual interest to the two societies. This year the meeting will be held at the Hotel Gibson, Cincinnati, Ohio, Oct. 20 and 21, 1947.

The program will consist of nine technical papers on coal production and utilization, two luncheons, and a banquet.

One of the features will be the complete report of the underground-gasification experiment at Gorgas, Ala.

The tentative program follows:

MONDAY, OCT. 20

9:00 a.m.

Registration

10:00 a.m.

Technical Session (I)

Further Tests of Dutch Cyclone Coal Washer, by H. F. Yancey and M. R. Greer

The Dorrance Colliery Cleaning Plant, by T. R. Workman and H. D. Bowker

12:30 p.m.

Luncheon

Toastmaster: D. C. Weeks

Motion pictures: Studies of Spreader Stokers, by Otto de Lorenzi

2:00 p.m.

Technical Session (II)

Influence of Atmospheric Stability on Atmospheric Pollution, by H. F. Hebley

Influence of Condensation Nuclei on Atmospheric Pollution, by Hans Neuberger

A Look at Ohio's Fuel Situation in 1947, by R. F. Stilwell

7:00 p.m.

Banquet

Toastmaster: J. E. Tobey

Speakers: Milton H. Fies, Louis C. McCabe, and W. C. Schroeder

Subject: Underground Gasification

TUESDAY, OCT. 21

9:30 a.m.

Technical Session (III)

Panel Discussion on the Application of Combustion Equipment in Small Plants, by Carl E. Miller. Speakers are: R. L. Beers, C. A. Reed, H. B. Lammers, J. F. Barkley, Harold E. Hermann, and W. H. Pugsley

12:30 p.m.

Luncheon

Toastmaster: Evan Evans

Speaker: Ollie M. James

Subject: Just an Innocent Bystander

2:00 p.m.

Technical Session (IV)

A.I.M.E. Preparation Committee Study of the Increase in Moisture Content, by T. W. Guy

Sectionalizing Power Distribution Underground, by A. L. Barrett

Free Swelling Indexes of Some Alabama Coals, by R. Q. Shotts

Registration Act Passed in California

TWO years of effort on the part of engineering organizations in California inspired largely by The Los Angeles Engineering Council was rewarded recently by passage of the Professional Engineers' Act, A.B. 1930 of the State of California.

The act establishes a public corporation known as "The Professional Engineers' Association of California" and specifies that "only persons who are members of the association and registered or licensed as professional engineers" under the provisions of the act, are entitled to call themselves professional engineers or practice in any branch of professional engineering.

The new law in effect broadens the base of the old Civil Engineers Act under whose provisions civil engineers were required to register with the State Board of Registration for Civil Engineers for the past 20 years. A grandfather clause will be in effect for two years, after which both a written and oral examination will be required to become a registered professional engineer.

Six thousand dollars was contributed by engineers in San Francisco, Sacramento, San Diego, and Los Angeles, to publish and distribute a model act proposed by the California Sections of the Founder Societies.

Lignin Conference Announced

THE Northeastern Wood Utilization Council, New Haven, Conn., has announced its forthcoming conference on lignin chemistry and applications. The symposium will be in co-operation with Yale University, New Haven, Conn., and will be held on September 19, 1947, in the Sterling Chemistry Laboratories.

Lignin, the binding material of the cellulose in wood has been termed the "largest waste in industry," as sulphite pulp mills dump 1,750,000 tons of it annually, while soda and sulphate mills can make available another 1,250,000 tons. The 30,000,000 tons of sawmill waste and more than five times that amount of agricultural wastes should indicate that lignin is wasted.

The conference will examine critically the progress in lignin chemistry and technology. It will include papers of a fundamental nature, as well as the latest information on the commercial utilization of lignin. Topics for further research will also be suggested at the symposium.

Hungarian Student Awarded 1947 Calvin W. Rice Scholarship

THE awarding of the Calvin W. Rice Memorial Scholarship was resumed this year by the Woman's Auxiliary to The American Society of Mechanical Engineers, with an award to a graduate student of Budapest, Hungary.

The award is made in the sum of five hundred dollars to a foreign student of ability and limited resources as an aid to graduate study in engineering in this country.

This year's award was made to V. Szebehely, graduate of the Technical University of Budapest, with a doctor's degree in the technical sciences. The award of the Calvin W. Rice Memorial Scholarship is made through the services of the Institute of International Education, through whose efforts arrangements have been made for an additional scholarship for Dr. Szebehely to study at New York University, New York, N. Y.

Meetings of Other Societies

September 8–12
Instrument Society of America, second annual conference and exhibit, The Stevens Hotel, Chicago, Ill.

September 15–19
American Chemical Society, 112th national meeting, New York, N. Y.

September 17–18
Society of Automotive Engineers, Inc., national tractor meeting, Hotel Schroeder, Milwaukee, Wis.

September 17–26
National Machine Tool Builders' Association, machine-tool show, Dodge Chicago Plant, Chicago, Ill.

September 22–25
Association of Iron and Steel Engineers, annual meeting, Hotel William Penn, Pittsburgh, Pa.

September 24–27
Technical Association Pulp and Paper Industry, acid pulping meeting, Hotel Nicollet, Minneapolis, Minn.

September 29–October 1
American Institute of Chemical Engineers, regional meeting, Hotel Statler, Buffalo, N. Y.

October 1–2
Army Ordnance Association, annual meeting, Waldorf-Astoria Hotel, New York, N. Y. (Second day's session will be held at Aberdeen Proving Grounds, Md.)

October 1–2
American Society of Tool Engineers, semi-annual meeting, Hotel Statler, Boston, Mass.

October 1–2
Institute of the Aeronautical Sciences, Inc., air transport meeting, New York, N. Y

October 2–4
Society of Automotive Engineers, Inc., national aeronautic meeting and aircraft engineering display, Biltmore Hotel, Los Angeles, Calif.

October 6–8
American Gas Association, annual meeting, Cleveland, Ohio

October 6–10
National Safety Council, Inc., 35th national safety congress and exposition, The Stevens and Congress Hotels and the Palmer House, Chicago, Ill.

October 15–17
American Society of Civil Engineers, fall meeting, The Hotel Roosevelt, Jacksonville, Fla.

A.S.M.E. Junior Committee Considers Specific Proposals at Second Meeting

THE A.S.M.E. Junior Committee at its second meeting held in New York on July 11, 1947, rolled up its sleeves and plunged into a discussion of the age-old problems that confront any young man who having prepared himself for a profession, sets out to find his place in it. Out of the discussions came a general agreement on problems which face the junior member immediately after graduation and those which sometimes torment him five years out of school. Several proposals were considered and a decision was made for immediate action of one of them.

To provide junior members with a forum before which they may express their ideas on professional matters, the Committee recommended and the Publications Committee approved a Junior Section to be published monthly in the A.S.M.E. News Section of MECHANICAL ENGINEERING. The section is to be inaugurated in the October issue of the magazine and will contain news of junior activities, letters from juniors, and other articles of particular interest to them.

According to the Committee there are 11,000 juniors in the society. Of these more than 6,000 are under 30 years of age. In adjusting themselves to professional life, these young men are faced with many perplexing decisions which are especially difficult without advice from older members of the profession.

The period immediately following graduation is a difficult period of transition from the small genial world of the campus to the complicated impersonal one of industry, the Committee agreed. At this time, the new graduate must decide not only the field of engineering he is to enter, but also which of several jobs he should take. Once in the plant, he runs the hazard of union pressure and is tantalized by union advantages. His first job, like as not, is a routine affair far removed from his conception of creative engineering developed by years of concentrated study. Alone in a strange town, he misses the fellowship of campus life. In his new environment, he is tormented by a desire for recognition and is bewildered by the insignificance of his place among the ramifications of an industrial organization.

About five years out of school his painfully acquired confidence is likely to dissolve into a soul-searching self analysis. He will ask himself: Have I progressed far enough? Am I in the right work? Am I with the right company? Where shall I be ten years from now? Hard on the heels of these questions will be others. Must I join a union? Should I apply for registration? Am I prepared for my next job? Have I done enough outside reading? What should I study? Above all, he will ask about his job: Is my salary right? Does it give me adequate opportunity for advancement? Have I reasonable security? Does it help me feel like an engineer? These questions hold the seeds of personal crises which often can be dispelled by advice from an experienced engineer.

The Committee felt that the Society should assume responsibility for advising junior members who are entering upon these two difficult periods of professional adjustment.

As one way of offering advice, the Committee discussed a proposal of the A.S.M.E. Washington Section which suggested organization among the Sections of boards of personal advisers to whom junior members could come for consultations on personal problems about their work. The plan envisages a confidential relationship between experienced members of the profession and young men who have not yet found their place in it or who are dissatisfied with their progress and need advice and guidance. The plan was favorably received and will be developed further by the Committee.

Among the Committee's immediate projects is one calling for the revitalization of Junior groups which have diminished from a high of 34 in 1938 to less than 10 in 1947. Another is the preparation of an outline for a junior program to guide administrative committees of the Sections in planning events of interest to juniors.

Members of the Junior Committee are: Donald E. Jahncke, chairman; Charles H. Carmen, Jr., vice-chairman; Phillip Allen, George B. Thom, and H. C. Thuerk.

The Junior Committee urges junior members to look for the Junior Section in the October issue of MECHANICAL ENGINEERING, and to express themselves freely and fully on Society and professional matters which have been causing them concern. These ideas will be published in the Junior Section for national distribution among A.S.M.E. junior members. Their message is: If you are a junior member and want to be heard, now is the time to speak.

Greenwich Village Notes Holley's Birthday

GREENWICH Village, the art community in New York, N. Y., which surrounds Washington Square Park and the Holley Memorial which stands in it, took note of the birthday of Alexander Lyman Holley, founder and honorary member in perpetuity of The American Society of Mechanical Engineers as that of one of the "builders of America."

The community's weekly newspaper *The Villager* paid tribute to Holley's memory in its issue of July 24, 1947. In addition to an editorial *The Villager* published a prominent front page photograph of the Holley memorial and the life story "Who Was Holley?" which was published in the July issue of MECHANICAL ENGINEERING, pages 564 to 566.

The editorial said in part:

Holley's statue stands in Washington Square, almost completely forgotten except by the world of engineering. This is a strange paradox in a country so ready to sing the praises of the men who played important roles in her building; and Holley was a pioneer in the best American tradition.

The deeds of men like Holley continue to be a source of wonder to present-day Americans. How could they do so much in the course of their lifetimes? Aside from their natural genius, what drove them to such complete absorption and devotion to their work? Edison, Morse, the Wrights, and Holley are but a few; many more had the spark.

Perhaps it was just the love of the game, perhaps it was the creative instinct in the process of fulfillment, or maybe it was a desire for fame and fortune. No doubt these are factors; but note that the work of all these men have been of great benefit to America and her people, notwithstanding some of the obvious abuses of later generations.

COMMITTEE MEMBERS OF THE WOOD INDUSTRIES DIVISION AT THE 1947 A.S.M.E. WOOD INDUSTRIES CONFERENCE HELD AT MADISON, WIS., JUNE 12–13, 1947

(*Standing, left to right:* Roger R. Smith, Gardner, Mass.; Charles R. Nichols, Jr., Jersey City, N. J.; Charles B. Norris, Madison, Wis.; James C. Mathewson, Madison, Wis.; Thomas D. Perry, Moorestown, N. J.; and O. B. Schier, A.S.M.E. staff. *Seated, left to right:* Chester L. Babcock, New York, N. Y.; F. F. Wangaard, secretary, executive committee, New Haven, Conn.; C. B. Lundstrom, chairman, Executive Committee, Little Falls, N. Y.; and R. B. Sargent, Conshohocken, Pa.)

U. S. A. National Committee for World Engineering Conference Formed

THE Engineers Joint Council through its Committee on International Relations has taken the first step toward formal organization of the U. S. A. National Committee for World Engineering Conference which is expected eventually to represent all engineering societies and organizations at the professional level in matters concerning the world engineering profession.

At a meeting in the Engineering Societies Building, New York, N. Y., on August 4, 1947, seven members of the American Society of Civil Engineers, The American Society of Mechanical Engineers, and the American Institute of Chemical Engineers agreed to sponsor the U. S. A. National Committee. They established an Executive Board pro tem of the new organization and agreed to postpone formal organization of the U. S. A. National Committee for World Engineering Conference until American engineering organizations have acted upon invitations and could participate in an organization meeting. A draft charter was discussed and approved.

To assure U. S. participation in the next meeting of the Executive Board of the World Engineering Conference to be held in Zurich, Switzerland, Sept. 9 to 11, 1947, the sponsors authorized Stewart E. Reimel, secretary, E. J. C. Committee on International Relations, and G. F. DuBois, member A.I.Ch.E. to represent the U. S. A. National Committee at the Zurich meeting.

These actions were taken after a review by C. E. Davies, secretary A.S.M.E., of the history of the International Technical Congress and the World Engineering Conference, whose organization was initiated during the last meeting of the International Congress in Paris in September, 1947. At the W.E.C. organization meeting C. E. Davies, F. B. Farquharson, member A.S.C.E., and E. S. Lee, member A.S.M.E., represented the Engineers Joint Council, a constitution was drafted, a provisional executive board organized and arrangements made for subsequent meetings. Fenton B. Turck, member A.S.M.E., president, Turck Hill and Company, New York, N. Y., was named the American delegate on the W.E.C. Council and Executive Board. Mr. Turck will not be able to attend the Zurich meeting.

An account of the organization of the W.E.C. was published in Mr. Turck's article "The American Stake in World Engineering," which appeared on pages 142 to 144 of the February, 1947, issue of MECHANICAL ENGINEERING.

According to the charter for the U. S. A. National Committee, the purpose of the Committee is "to foster co-operation between the engineers and engineering societies in the various nations of the world" by "helpful co-ordination that will reduce confusion and assist communication" among world engineers.

The following members were chosen to constitute the Executive Board pro tem: B. A. Bakhmeteff, F. B. Farquharson, and E. P. Goodrich for the A.S.C.E.; M. L. Cooke, R. M. Gates, and F. B. Turck for the A.S.M.E.; and F. J. Curtis and A. B. Newman for the A.I.Ch.E.

Membership Development Attains One Third Quota

FOLLOWING a meeting of the A.S.M.E. National Membership Development Committee in Chicago, Ill., June 16, 1947, it was disclosed that one third of 1946-1947 quota of 440 applications for Society membership had been obtained by the 13 Membership Development Committees organized by A.S.M.E. Sections in various Regions.

There was a general feeling that the drive had "bogged down" but a study of the program revealed no apparent reason for the disappointing results.

The Committee reviewed new membership development material, exchanged experiences, and pledged to intensity its activities during the remaining fourth quarter of the current administrative year.

Iowa State College Honors T. R. Agg

THE 1947 Marston Medal of the Iowa State College, Ames, Iowa, was awarded to Thomas Radford Agg, former member of the faculty, who served as dean of engineering and director of the engineering experimental station from 1932 to 1946.

Dean Agg, who died shortly after the award was announced, was an authority on highway engineering.

Divisions Consolidated by Bureau of Standards

THE consolidation of two divisions of the National Bureau of Standards, Commercial Standards and Simplified Practice, into a single division called Commodity Standards has been announced by Dr. E. U. Condon, director of the Bureau.

The new Commodity Standards Division will continue the Bureau's co-ordinating role in the development of voluntary simplified practice recommendations and commercial standards with industrial and technical groups. In addition, the division will be responsible for co-ordinating Bureau work for the Federal Specifications Board. Edwin W. Ely, member A.S.M.E., former chief of the Simplified Practice Divisions has been appointed as chief of the division and F. W. Reynolds, former acting chief of Commercial Standards, as assistant chief.

Keep Your A.S.M.E. Records Up to Date

HEADQUARTERS depends on its master membership file for answers to hundreds of inquiries daily pertaining to its members. All other Society records and files are kept up to date through changes processed through it. The listings in future A.S.M.E. Membership Lists will be taken directly from the master file. It is important to you that it lists your latest mailing address and your current business connection.

The mailing form on this page is published for your convenience. You are urged to use it in reporting recent changes.

Your mailing address is important to Headquarters. Please check whether you want your mail sent to home or office address. Under "Position or Title" report title and nature of work, as for example, "M.E. in charge of maintenance" or "Engr. in charge of design," or "V.P. in charge of manufacturing."

A.S.M.E. Master-File Information

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Name..
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Home Address..
Street City Zone State

Name of Employer..

Address of Employer..
Street City Zone State

Product or Service..

Position or Title..

Notify Headquarters Promptly of Any Future Changes

A.S.M.E. Members Among New A.M.A. Officers

HAROLD V. COES, past-president and Fellow A.S.M.E., vice-president, Ford, Bacon and Davis, Inc., New York, N. Y., was elected chairman of the executive committee of the American Management Association, at a meeting of the Association on June 16. Among the new directors is R. E. Gillmor, member A.S.M.E., vice-president, the Sperry Corporation, New York, N. Y.

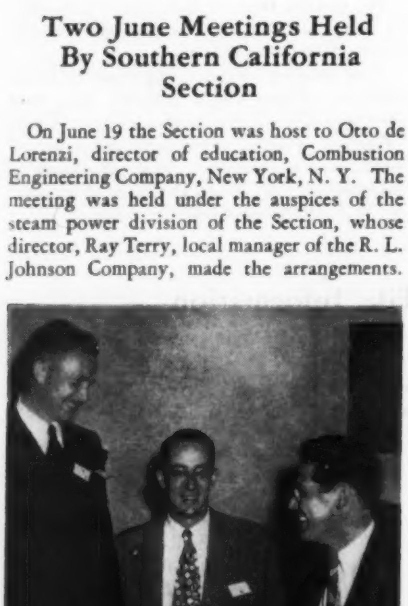
Sections

Officers Elected for Atlanta Section

AT A dinner party held on June 27 at the East Lake Country Club, Atlanta, Ga., at which 56 were present, the following officers were elected for the coming season: T. E. Smith, chairman; Roger A. Martin, vice-chairman; Paul H. Nichols, secretary-treasurer. The speaker was Eugene W. O'Brien, president A.S.M.E., whom it was a pleasure to greet. Mr. O'Brien gave a very able address on "Public Relations Between Employer and Employee," and dealt in his talk with the question as to how the new Labor Bill will affect these relations.

Two June Meetings Held By Southern California Section

On June 19 the Section was host to Otto de Lorenzi, director of education, Combustion Engineering Company, New York, N. Y. The meeting was held under the auspices of the steam power division of the Section, whose director, Ray Terry, local manager of the R. L. Johnson Company, made the arrangements.



ONE TALL TALE AFTER ANOTHER AT THE A.S.M.E. SOUTHERN CALIFORNIA SECTION MEETING OF JUNE 26

(*Left to right:* E. Wayne Young, Robert Cornog, and Don Jones.)

A.S.M.E. SOUTHERN CALIFORNIA SECTION IS HOST TO OTTO DE LORENZI

(*Left to right:* Ray Terry, V. A. Peterson, chairman A. S. M. E. Southern California Section, Otto de Lorenzi, and R. L. Daugherty.)

Mr. de Lorenzi's address concerned the burning of various fuels in furnaces. The colored films illustrating the lecture were excellent and helpful toward a better understanding of combustion activity.

On June 26 at the Pasadena Athletic Club a meeting was arranged by the junior members of the Section, under the leadership of W. Wayne Young. The speaker was Dr. Robert Cornog, nuclear physicist. His subject was "The Commercial Application of Nuclear Energy." The talk, which was an excellent discussion of the therapeutic and fuel-generating possibilities of nuclear energy, was illustrated. At this meeting officers for the coming year were introduced, namely: V. A. Peterson, Elliott Company, chairman; A. R. Weigel, Consolidated Steel Corporation, vice-chairman; John K. Morris, Western Gear Works, secretary-treasurer. A souvenir gavel was presented to the retiring chairman, Homer C. Reed.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3.50 per quarter or $12 per annum, payable in advance.

New York	Chicago	Detroit	San Francisco
8 West 40th St.	211 West Wacker Drive	109 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

INDUSTRIAL ENGINEER, B.S. and M.S. degrees, 25 years' experience in organization and administration of comprehensive program of industrial engineering including plant layout, incentives, methods, time study, materials handling, standards, budgets, job evaluation, wage administration, cost reduction, foreman training, reports. Professional license Pennsylvania. Able organizer and administrator. Available as chief industrial engineer or assistant to top-line executive. Me-205.

MANUFACTURING ENGINEER, B.S.M.E., Purdue 1935, with 12 years' diversified experience in production and industrial engineering. Experience includes responsible positions in the machine-tool, glass, aircraft and metal-working industries. Me-206.

EXECUTIVE ENGINEER, professional registra-

[1] All men listed hold some form of A.S.M.E. membership.

tion, 23 years' experience: power-plant design, thermodynamics, steam turbines, centrifugal pumps, geared and exhaust-turbine-driven superchargers, centrifugal and positive-displacement compressors, gas turbines for marine, aircraft, and industrial applications. Proved ability to conceive and develop original engineering and design ideas. Desires top position in research, manufacturing, or with established consultant. Me-207.

MECHANICAL GRADUATE, Canadian, age 26, married. At present, plant engineer of plant connected with processing of cotton and paper products. Experienced in general design, maintenance, and plant engineering, production and maintenance planning. Desires position on West Coast, preferably Pacific Northwest. Me-208.

MECHANICAL ENGINEER, graduate, registered power engineer, 26 years' diversified experience in responsible positions. Many patents issued to me in mechanical, electrochemical, and metallurgical processes. Director of research, 5 years. Prefer position on West Coast or foreign, but will go anywhere. Me-209.

MECHANICAL ENGINEER, Tau Beta Pi, $1^1/_2$ years' experience in heat-transfer research by electrical analogy, also considerable experience in electronic sealing of thermoplastics. Possesses executive ability and initiative. Me-210.

MECHANICAL ENGINEER, B.S.M.E., 24, Four years' experience in research and development of compressors, turbines, and large-scale internal-combustion aircraft engines. Familiar with design and machine-shop methods. Me-211.

MANUFACTURING ENGINEER, 36, graduate M.E., heavy experience as production engineer, superintendent, and works manager on carburetors, gasoline engines, electronic instruments, and tooling. Specialized in mass-production techniques. Me-212.

MECHANICAL ENGINEER, married, 25 years' centrifugal-pump-engineering executive experience. Familiar all engineering and manufacturing phases. All types, industrial domestic. Registered power engineer. Eastern location preferred. Available on short notice. Me-213.

MECHANICAL ENGINEER, B.S., M.S., 23, single. Now supervising aerodynamic research. Desires position assisting in layout and estimating of heating, ventilating, and air-conditioning equipment. Prefers New York, N. Y. Will travel. Me-214.

POSITIONS AVAILABLE

ASSISTANT TO PLANT MANAGER, mechanical engineer or equivalent, preferably with experience in tube-bending, expanding, swaging, spinning, forming, flash and pressure welding, for small shop. Write giving full information. \$4000. Northern New Jersey. W-9297.

MECHANICAL OR CHEMICAL CONSTRUCTION ENGINEER, 40–45, with at least ten years' installation experience, to take charge of equipment erection in chemical processing plant. Must have considerable experience in New Jersey. \$5000–\$6000. Northern New Jersey. W-9352.

DESIGN AND DEVELOPMENT ENGINEER, mechanical graduate, with experience in design of heavy hydraulic high-pressure machinery. Salary open. South. W-9379.

ASSISTANT TO EXECUTIVE, 40–45, should have at least ten years' industrial management experience, including costs, finance, personnel relations, planning, for company dealing with machine-shop operations. Write giving salary desired. Brooklyn, N. Y. W-9382.

ENGINEER, mechanical or industrial engineering graduate, 25–35, with some supervisory background and at least five years' general industrial-engineering experience, including motion and time-study techniques and practice, general methods and procedure analysis, cost analysis, and wage administration, to take charge of methods and time-study department. Knowledge of plastics helpful. \$4500–\$5500 a year. Central New York State. W-9394.

FACTORY SUPERINTENDENT, graduate, under 45, for manufacturer of commercial laundry machines. Must know machine shop; sheet metal, mostly monel metal; select, train, and direct personnel. Company employs about 50 people. Should be familiar with assembly of large power-operated units. Salary open. New York, N. Y. W-9403.

SALARY JOB ANALYST, 30–35, with three to five years' wage and salary-analysis experience or related work, to aid in developing and writing up wage or salary job descriptions; evaluations, classifications, and developing wage and salary charts. About \$3600 plus traveling expenses. Venezuela. W-9416.

ASSISTANT SUPERINTENDENT with thorough knowledge of tool designing, toolmaking, and press operation to produce parts at minimum costs. Should be conversant with proper tool steels to use for different tools and have experience in producing parts without intermediate annealing, for metal-stampings concern. Massachusetts. W-9421.

PROJECT ENGINEER, not over 45, chemical graduate, to head up department for large firm of constructors, in connection with all process-engineering work. \$10,000–\$12,000 a year. New York, N. Y. W-9445.

ENGINEERS. (*a*) Powerhouse superintendent, 30–35, preferably mechanical graduate, with at least three years' experience, to take charge of large powerhouse including operation and maintenance of boilers, auxiliary equipment, turbines, pumps, generators, etc. Must have New Jersey professional license. \$4800–\$6000.

(*b*) Powerhouse superintendent, preferably mechanical graduate, with experience as above, to take complete charge of operation of power plant including operation of Riley coal-fired boiler, etc. Will handle the operation of all distribution lines and numerous deep wells outside the plant. \$4800–\$6000 a year. New York, N. Y. W-9454.

SUPERINTENDENT, 40–50, with experience in automatic machinery or line production and knowledge of electric-arc-welding field, to take charge of manufacture of welding electrodes. Salary open. Midwest. Interviews, New York, N. Y. W-9482.

ENGINEER with five to six years' practical experience in factory efficiency, methods, plant layouts, et cetera, for paper-converting company. Massachusetts. W-9483.

SUPERINTENDENT, preferably mechanical graduate, with at least ten years' experience in machine-tool building, to be responsible for machining and assembly of machine tools. Must be able to build up organization to increase production and labor efficiency. Salary open. New England. W-9500.

SALES ENGINEER, mechanical graduate, 27–40, with some experience in the field of steam generation; any experience with water treating helpful, for representative of manufacturers of mechanical equipment. Territory: Maryland, District of Columbia, and Virginia. About \$5200 plus bonus. Headquarters, Washington, D. C. W-9509.

CHIEF INDUSTRIAL ENGINEER, 35–45, mechanical or industrial graduate, with at least 10 years' progressive experience covering time study, methods, work simplification in machining, stamping, assembling, to take charge of department for manufacturer of electromechanical products. \$7500 a year. Massachusetts. W-9510.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after Sept. 25, 1947, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Fellow, Member, Associate, or Junior

AGNI, EDWARD S., Detroit, Mich.
BAXTER, R. C., Nagpur, India
BENDECK, Z. E., Honduras, C. A.
BENDOT, JOSEPH M., Washington, Pa.
BLAIR, DONALD W., Cambridge, Mass.
BODMAN, ELMER PHILIP, Cincinnati, Ohio
BORCHER, CHARLES A., Silver Spring, Md.
BOTT, NEWTON JOHN, Toledo, Ohio
BRONSON, ROBERT W., Erie, Pa.
BURKE, MICHAEL J., Los Angeles, Calif.
CHAKRAVARTI, D. K., Calcutta, India
CLAPP, W. J., St. Petersburg, Fla.
CLARRIDGE, RALPH, Rochester, N. Y.
COLE, R. M., Schenectady, N. Y.
COLEMAN, THOMAS V., JR., Long Beach, Calif.
CROFTS, ALLYN J., Wilmerding, Pa.
CUNNINGHAM, JAMES B., Kingston, Ont., Can.
DALY, ROBERT A., Hartford, Conn.

Davis, Arthur B., Chicago, Ill. (Rt & T)
de Reot, Maurits P., Albany, Calif.
Derks, Richard J., Racine, Wis.
Dick, Carroll B., East Pittsburgh, Pa.
Di Maggio, Samuel S., Jr., Rochester, N. Y.
Flail, Edward N., Pelham Manor, N. Y.
Gaines, George D., Whittier, Calif. (Rt & T)
Garfinkel, Jack, New York, N. Y.
Gibbs, Winfield S., Croydon, Pa.
Gieck, Joseph F., East Chicago, Ind.
Gillman, Joseph L., Jr., Aldie, Va.
Glover, George E., Beaumont, Texas
Glover, L. E., London, England
Groneymeyer, F. G., Clayton, Mo. (Rt)
Groom, Vaughn Randall, Dearborn, Mich.
Guldenbecker, Albert, Chicago, Ill.
Hammond, Theodore E., Erie, Pa.
Hartman, C. Dan, Pittsburgh, Pa.
Hennessy, Carroll A., Syracuse, N. Y. (Rt & T)
Hess, Franklin E., Bala-Cynwyd, Pa.
Hesse, Herman C., Chicago, Ill. (Rt)
Hollister, K. L., Ridgewood, N. J. (Rt & T)
Hotchkiss, Clifford Jerome, Torrington, Conn.
Johnston, Robert J., Cambridge, Mass.
Kent, Alfred, Houston, Texas (Rt & T)
Klein, Hugo, Houston, Texas
Kraut, Ralph J., Fond du Lac, Wis.
Landberg, Erik G., Seneca Falls, N. Y.
Larrabee, Edward W., Locust Valley, N. Y.
Lathrop, James E., Jackson Heights, N. Y.
Leonard, John Wilbur, Penns Grove, N. J.
Lester, John C., State College, Pa.
Lofthus, Leon James, Washington, D. C.
Logan, Richard W., Boston, Mass.
Loubser, M. M., Pretoria, So. Africa
MacMeekin, R., Hamilton, Ohio
Mahaney, J. P., Blacksburg, Va. (Rt)
Maloney, W. G., Mexico, Mo.
Masiello, Michael A., New York, N. Y.
McCabe, Joseph C., Mountain Lakes, N. J.
McLellan, Findlay, Chaddsford, Pa.
McNair, R. S., Alloy, W. Va.
Mickle, E. L., Temiskaming, Quebec
Middleton, Claude E., Salt Lake City, Utah
Miller, Gilbert C., Erie, Pa.
Morrison, Howard A., Winchester, Mass. (Rt)
Mott, Clinton P., Queens Village, N. Y.
Murray, Fred W., Washington, D. C.
Neklutin, C., Normandy, Mo.
Otsuka, Tsuruo, Chicago, Ill.
Pierce, Jesse N., Kansas City, Mo.
Pitkin, Emerson S. B., Plattsburg, N. Y. (Rt. & T.)
Porter, Robert, Los Angeles, Calif. (Rt)
Ready, Joseph A., Bethlehem, Pa.
Redman, William J., Braddock, Pa.
Redue, Henry O., Jr., Annapolis, Md.
Redhard, J. C., Detroit, Mich.
Reinio, William Charles, Richland, Wash.
Rituper, R., Cleveland, Ohio
Roehrenbeck, Frank J., Jr., Oak Ridge, Tenn.
Roemer, Arthur J., Appleton, Wis.
Rogers, B. T., Los Alamos, N. M.
Roth, William Stewart, Los Angeles, Calif.
Rucker, T. W., Louisville, Ky. (Rt & T)
Saunders, Herbert, Brooklyn, N. Y.
Sembert, Peter, Saint Marys, Pa.
Senkus, E. R., Manhasset, N. Y.
Shaw, Bernard E., Penistone, nr. Sheffield, England
Smith, Earl C., Amityville, N. Y.
Smith, H. Gray, Greenville, S. C.
Smitzer, L. A., Chicago, Ill.
Stiles, Russell W., Staten Island, N. Y.
Thigpen, Cromwell Knight, Glen Lyn, Va.
Trejbal, Josef, Washington, D. C.
Tsu, T. C., State College, Pa.
Vander Eyk, Louis, Waterbury, Conn.
Verdesca, Anthony F., Fairview, N. J.
Vitelli, Anthony C., Lawrence Park, Pa.
Waltermire, William G., Cleveland, Ohio
Walther, Lorenz W., Philadelphia, Pa. (Rt & T)
Wendel, Clarence J., Philadelphia, Pa.
White, Robert H., Panama, R. de Panama
Williams, H. R., Chanute, Kansas
Wolfe, C. H., Detroit, Mich.

CHANGE IN GRADING

Transfers to Fellow

Brown, Richard P., Philadelphia, Pa.
de Lorenzi, Otto, New York, N. Y.
Keeth, J. A., Kansas City, Mo.
Murray, Thomas E., New York, N. Y.
Prentice, Donald B., Terre Haute, Ind.
Stueve, Winfred H., Oklahoma City, Okla.

Transfers to Member

Adler, Frank Read, Los Angeles, Calif.
Ambler, F. Marple, Allentown, Pa.
Applegate, Walter F., Wilmington, Del.
Aries, Robert S., Brooklyn, N. Y.
Bergin, Robert F., Garden City, Mich.
Bertrand, Louis, Wilmington, Del.
Bobrowsky, A. R., Berea, Ohio
Bounous, Edwin P., Huntington Station, N. Y.
Boynton, E. B., Richmond, Va.
Briggs, Fred, Jr., New York, N. Y.
Carter, Douglas, Berkeley, Calif.
Chattler, Leo Morse, Washington, D. C.
Coates, Robert Edwin, York, Pa.
Cowan, Edward L., Bogalusa, La.
DeBoo, Joseph H., Brookfield, Ill.
Dick, Howard D., Toronto, Ont., Can.
Elliot, Walter R., Buffalo, N. Y.
Enell, John W., Paterson, N. J.
Fetters, George H., South Langhorne, Pa.
Fredin, Roy W., Altadena, Calif.
Frohmuth, Robert L., Drexel Hill, Pa.
Greenwald, D. U., Newark, Del.
Harmon, W. T., Cincinnati, Ohio
Hind, John H., Jr., Los Angeles, Calif.
Jackson, Charles H., Arlington, Va.
Johnson, Allen P., Jr., Columbus, Ohio
Johnson, Ira O., Jr., Knoxville, Tenn.
Judge, J. Emmet, Asheville, N. C.
Kaprelian, Edward K., Long Branch, N. J.
Keiser, A. C., Jr., Atlanta, Ga.
Kells, O. C., Niagara Falls, Ont., Can.
Kenworthy, J. M., Jr., Ardmore, Pa.
Klein, E. W., Jr., Atlanta, Ga.
Larsen, Arild F., Momence, Ill.
Marsilius, N. M., Jr., Bridgeport, Conn.
Martin, Lee, Edwardsburg, Mich.
McDonald, Daniel E., Ansonia, Conn.
McLean, William George, Scranton, Pa.
Moore, Walter G., Berkeley, Calif.
Munson, Lloyd E., Fort Worth, Texas
Nelson, Edward, New York, N. Y.
Poor, Hustace H., New York, N. Y.
Reznek, Ben, Washington, D. C.
Roop, Frank S., Jr., Norman, Okla.
Stackhouse, H. L., New York, N. Y.
Stott, John E., Wallaceburg, Ont., Can.
Taylor, John Ellsworth, Kansas City, Mo.
White, W. Frank, Glendale, Calif.

Transfers from Student Member to Junior 205

Necrology

THE deaths of the following members have recently been reported to headquarters:

Carroll, Lafayette D., June, 1947
Clarke, Walter J., September 29, 1946
Finnegan, Joseph B., July 4, 1947
Hollis, Oliver N., June 13, 1947
Kennedy, John C., June 23, 1947
King, Norman M., August 1, 1947
Price, Joseph, July 8, 1947
Rea, Ralph G., July 11, 1947
Rollins, Lewis M., April 15, 1947
Smith, Vernon, April 13, 1947

A.S.M.E. Transactions for August, 1947

The August, 1947, issue of Transactions of the A.S.M.E. contains the following papers:

Design and Operation of Some Experimental High-Temperature Gas-Turbine Units, by A. D. Hughes
Metallurgical Considerations of Gas Turbines, by N. L. Mochel
Haynes Alloys for High-Temperature Service by W. O. Sweeny
Precipitation-Hardened Alloys for Gas-Turbine Service, by Howard Scott and R. B. Gordon (Parts I and II)
Materials for Power Gas Turbines, by C. T. Evans, Jr.
Nickel-Chromium Alloys for Gas-Turbine Service, by C. A. Crawford
The Horizontal Cyclone Burner, by A. E. Grunert, L. Skog, and L. S. Wilcoxson
Determination of Moisture Content of Coal by Means of Pulverizer Heat-Balance, by T. J. Finnegan and H. L. Smith
Specific Studies Pertaining to Tool Wear, Chip Characteristics, and Surface Finish of Free-Cutting Steels, by G. P. Witteman
Effect of Varying Relief Angles When Face-Milling Cast Iron With Sintered-Carbide Tipped Cutters, by O. W. Boston and W. W. Gilbert
Effect of Microstructure on Machinability of Cast Irons, Parts I and II, by Michael Field and E. E. Stansbury
Correction for Heat Conduction Through Longitudinal Baffle of Heat Exchanger, by A. M. Whistler
Shell-Side Coefficients of Heat Transfer in a Baffled Heat Exchanger, by H. S. Gardner and Irving Siller
Instrumentation for Flight Testing of Thermal Anti-Icing Systems, by W. C. Droege
Determination of the Thermal Correction for a Single-Shielded Thermocouple, by W. M. Rohsenow and J. P. Hunsaker
Electrically Heated Glove for Determining Local Values of Heat-Transfer Coefficients, by J. K. Goss